



THE
HETCH HETCHY WATER SUPPLY
OF SAN FRANCISCO

REPORT OF M. M. O'SHAUGHNESSY
CITY ENGINEER

TO

THE MAYOR, THE BOARD OF PUBLIC WORKS
AND THE BOARD OF SUPERVISORS
OF SAN FRANCISCO

MARCH, 1916



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CITY AND COUNTY OF SAN FRANCISCO

DEPARTMENT OF PUBLIC WORKS

BUREAU OF ENGINEERING

CITY HALL

March 25, 1916.

To the Honorable, the Mayor, the Board of Public Works and the Board of Supervisors of the City and County of San Francisco.

GENTLEMEN :

I hand you herewith my progressive report on the Hetch Hetchy Water Supply project.

The Hetch Hetchy Water Supply is a most stupendous enterprise and in its magnitude and its importance to the City of San Francisco, is second only to the rehabilitation of the City after the disaster of 1906. The work has been well begun and to insure its completion in a satisfactory and economical manner, it is essential that careful study be given to all features of the project by public officials in all departments of the City government and by interested citizens, so that the most effective co-operation can be had in the successful execution of this undertaking.

In this report will be found a broad review of the project as a whole, and for purposes of comparison, there is also given a brief description of two other important American water supply developments of recent years.

A detailed statement of work done during the past year and a program for its continuance and for the initiation of new work is given. The recommendations for future work have been very thoughtfully considered and it is strongly urged that all appropriations requested for this year's work be made available at once.

Respectfully submitted,

M. M. O'SHAUGHNESSY,

City Engineer.



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REVIEW OF THE HETCH HETCHY WATER SUPPLY PROJECT

A substantial amount of preliminary work has been done on the construction of the Hetch Hetchy Water Supply of San Francisco during the past year, and considerable additional work is necessary before any of the vital permanent parts of the system can be commenced. The changes in the membership of the governing body of the city and in the personnel of the various committees make it pertinent at this time to set forth a broad review of all the work already done and the general plan under which the future construction, both preliminary and permanent, will be prosecuted.

Enthusiastic amateur critics among the public at large are prone to demand tangible results at the very inception of any great public improvement and to indulge in unbalanced criticism, with a lack of knowledge of the facts, at the expense of the officials in charge when they find that much time must often elapse between the voting of bonds and the commencement of active work on a great project. Undertakings of such magnitude as our great mountain water supply have to be properly considered and balanced in every detail. In every similar successful enterprise there has been a preliminary period of organization and preparation which has often been the most difficult part of the whole project.

Further, after construction has been started, there is a certain minimum time in which different portions of the work may be finished, which is generally determined by the maximum number of workmen who can be economically employed on certain units of the system.

Types of Construction

The Hetch Hetchy aqueduct will be a combination of pipe lines and tunnels. Pipe lines can be divided into sections of any size desired; the work on each section is in the open and can in general be prosecuted almost as fast as the materials can be delivered to the job, so that progress on this class of construction is quite rapid. The speed of tunnel construction, however, is absolutely limited to the rate of progress of the men working on each heading, whose number cannot be increased because there is no room for more. On a concrete dam, progress is limited by the space available for the construction plant. All these things must be considered together and a program arranged under which the divisions of the project requiring the longest time for construction will be begun earliest, the other divisions following in order so that all will be brought to completion as nearly as possible at the same time.

The relation between preliminary work and permanent construction on such a project as the Hetch Hetchy Water Supply, and the time required for completion, are best realized after comparison with other similar works. In recent years there have been only three water supply developments in America of a size and nature to compare with the Hetch Hetchy. They are the Metropolitan

Water Supply System, shared by Boston and neighboring cities, which has been in successful operation for some years; the Owens River supply of Los Angeles, recently completed and partially put in operation; and the Catskill development of the City of New York, now nearing completion.

THE LOS ANGELES AQUEDUCT

This entire development, from the Owens River intake to the terminal receiving reservoir near Los Angeles, has a total length of 223.4 miles, classified as follows:

Open unlined canal.....	23.8	miles
Lined uncovered canal.....	38.9	"
Lined and covered conduit.....	97.7	"
Tunnels	42.9	"
Steel siphons—pressure	9.4	"
Concrete siphons	2.6	"
Concrete flumes	0.2	"
Reservoir length	7.9	"
<hr/>		
Total	223.4	miles

The aqueduct is designed for a capacity of 260 million gallons daily, which can be used in transit to develop electric power averaging 49,000 horsepower. The cost to date is about \$27,000,000, and water is being delivered, but no power has as yet been commercially developed.

In September, 1905, the matter of bringing Owens River water to Los Angeles was presented to the people, who by a 14-to-1 vote passed a bond issue of \$1,500,000 for the purchase of lands and the preliminary investigation. A second bond issue was ratified in June, 1907, and in November, 1907, active work on permanent construction was begun on one division. At the end of the year 1908, six divisions were under way; in 1909, nine divisions; in 1910, ten, and in 1911, the entire line of eleven divisions. On April 1, 1910, the work was estimated to be 65% complete, and it was then predicted that the aqueduct would be finished by May 1, 1912. In November, 1913, the first water was delivered at the terminal point and the aqueduct was turned over to the Board of Public Service Commissioners for operation, though much work remained (and still remains) to be done on hydro-electric power development, and no power has yet been marketed from the completed system.

From the inception of the aqueduct plans the project had the fullest possible co-operation of the officials of the United States Government and all necessary legislation was put through Congress with little or no opposition.

What the Chief Engineer of the Los Angeles Aqueduct Says

Mr. Wm. Mulholland, Chief Engineer of the aqueduct, gave a very brief general view of the construction in an address before the League of California Municipalities, reported in "Pacific Municipalities," issue of November, 1915, page 542:

"We went to work on the scheme, and in seven years we finished it—that is, from the time of the beginning of construction. We turned the first shovel-

ful of dirt in 1907, and we had the celebration of the completion of the aqueduct, although it was not totally completed—there were some tunnels that had to be done, but they could be by-passed by turning the water around them—in 1913—that made six years, and we were really seven years on the job, because there was a year's more work that had to be done afterwards.

“ . . . The aqueduct really was a very bold project in many ways. We had to pass through a country that was wholly uninhabited, that was forbidding in the extreme. We had to lay 320 miles of water pipe, and water construction. We had to build power lines, and roads, four or five hundred miles of roads, trails, telephone lines. We spent altogether \$4,000,000 in getting ready for the job. That was the most trying time in the existence of the work. We were all fearful that some diligent taxpayer might arise and say, ‘Here, you have spent \$4,000,000, and you haven’t done a dollar’s worth of work yet,’ which would have been absolutely true. So far as the actual construction of the aqueduct was concerned there had not been a dollar’s worth of work done when we had \$4,000,000 spent. You can imagine that I was in a timid state of mind. It was always impressed on me, all through my life, that it paid to get a good ‘ready’ on. I didn’t want to see the work start until it was completely ready. And you could not properly start without doing that. You had no transportation systems. There was nothing but miles and miles of desert waste to go over. There was no water, no power, we built our own cement plant on account of the excessive transportation cost.”

Report of the Board of Consulting Engineers

After the first bond issue, more than a year was spent in preliminary investigations and surveys, and then a board of consulting engineers was appointed to examine the ground, review the work done, estimate the cost of construction and time required, and suggest changes. This board spent six weeks on its work and submitted a report dated December 22, 1906, which is printed in full in the First Annual Report of the Los Angeles Aqueduct. The following excerpts contain much that is of general application to all great water supply works:

“Modifications of Plan:

“In a work of this magnitude and on such bold lines, many trial routes must of necessity be surveyed, their cost estimated and their advantages compared before the final line for construction is laid down. In an aqueduct and reservoir project more trial lines are needed than on a railroad project because of the necessity of following a gradient along which water will flow with velocity rapid enough to prevent sedimentation and not so rapid as to produce scour, and because of the importance of distributing the fall so as to lessen the diameter and cost of the more expensive portions of the work, and adapt to each type of ground the type of conduit best suited for utilizing the natural resources of the neighborhood in material for concrete and masonry.

“Although it is now certain that the best general line of location has been reached, many local variations are still possible, and six or more months of

further study by your engineers may well be devoted to this matter of final location."

"Time Required to Complete the Project as Outlined

"In our opinion five years is the minimum time in which the projected works can be completed so that water from the Owens River can be delivered into the San Fernando Valley.

"The controlling feature in determining the time is the Elizabeth Lake tunnel, the longest on the line, which will be about 25,000 feet in length, exclusive of the deep approaches at its two ends, and which must be driven from only four headings, two of which will start from a shaft about 350 feet in depth, located in the valley near Elizabeth Lake. It will take the larger part of a year before work can be actively begun on the tunnel proper, and about four years more for the excavation of the tunnel and for lining it throughout with concrete masonry.

"Five years also appears as little time as may be prudently reckoned for the completion of the long series of shorter tunnels in the rugged country between Little Lake and the north end of the Antelope Valley section of the conduit.

"Due consideration of economy dictates that work should not be begun on these northerly tunnels until the railroad pertaining to the aqueduct has been extended far enough north to give convenient access to them, and until suitable power plants have been provided. . . .

"While these northerly tunnels are all of them short in comparison with the Elizabeth Lake tunnel and any one could be constructed much more quickly, there will be economy in avoiding unnecessary duplication of plant for carrying them all on simultaneously, and five years from the present time appears little enough time to allow for completing them all."

"Engineering Organization.

.
 "The work of building a water-tight and durable aqueduct, erecting safe and stable dams, and of constructing the great steel siphon pipes which will be required is of a far more exacting character than a railroad construction.

"The Los Angeles Aqueduct is a work of such magnitude and extends over so many miles of territory somewhat remote from the base of supplies, that it will be a physical impossibility for the chief engineer and the principal assistant engineer to be upon all parts of the work frequently enough to give the quick decision that is necessary for overcoming obstacles. *It will, therefore, be essential to have in the field engineers of proved executive skill and resourcefulness, who are expert in the line of work which they are to supervise. We recommend substantially the plan of organization which has been successfully adopted upon the Metropolitan Water Works of Massachusetts and upon the New York Aqueduct which is now being prepared for construction.* On the Metropolitan Water Works, representing about the same cost as the Los Angeles Aqueduct, but covering an extent of not more than sixty miles, and where all parts of the line were easily accessible, five of these skilled engineers, known as department engineers, were employed, and all of them were men

who had had sufficient experience to enable them to fill a position as chief engineer upon an important work.

"In New York, although the work has not yet advanced beyond the preliminary stage, five department engineers of this high grade are now employed. Consulting engineers were also connected with both of these works continuously.

"Our recommendation is, therefore, that under the chief engineer and the principal assistant or deputy chief engineer the work be divided into several main departments, each placed in charge of a department engineer having his principal office near the work which he is to supervise.

"In order to secure suitable men for these positions, *it will be true economy to pay liberal salaries sufficient to attract men from other work in these times when the abler engineers are all busy*, rather than to take men of less ability and unproved executive skill.

"There should be an efficient staff at headquarters to prepare designs for the work of construction and to make the necessary studies and investigations.

"The above recommendations are founded upon the experience on similar large aqueducts where most of the work has been done by contract. If this work is to be done in large part by day labor a somewhat different organization would be required, including men of special skill in several branches of the work."

Relation of Preliminary and Overhead Costs to Total Cost

Cost accounts were kept in great detail. The following summary of cost of construction to May, 1914, is taken from a report by O. E. Clemens, who supervised the cost accounting:

Waterway construction, covering the direct cost of all features of the aqueduct which are permanently useful for the conveyance of water, but excluding the cost of preliminary and auxiliary construction.....	\$15,942,489
Auxiliary expense, covering cost of water supply for construction purposes, roads and trails, buildings, telephone lines, power distribution lines, equipment and miscellaneous items.....	3,777,708
Total cost comparable to total cost of preliminary construction and payments on contracts if the work had been done by contract instead of by day labor	\$19,720,197
Overhead expense, covering—	
preliminary engineering	\$399,588
field administration	371,242
general office	730,200
Total waterway cost to May, 1914.....	\$21,221,227
This does not include lands and rights of way, cement mill and additional construction for power purposes, which, together with the expenditures since May, 1914, bring the total at the present time up to about..	<u>\$27,000,000</u>

Organization of Force

The organization of the engineering force and its auxiliaries during the construction period is shown diagrammatically on Exhibit "L," attached hereto.

The work was done almost entirely by day labor.
The maximum number of men employed was 3814.

THE CATSKILL WATER SUPPLY OF NEW YORK CITY

This project is of particular interest in comparison with the Hetch Hetchy, as in many features it resembles the Hetch Hetchy project as now planned. Its high concrete dams, tunnels, cement lined pipes, submerged pipes, and many details, afford invaluable lessons to be observed in the design and construction of the Hetch Hetchy works.

The Catskill development adds to the water supply of New York City 250,000,000 gallons daily from the watershed of Esopus Creek. This water is impounded in the Ashokan Reservoir, whose available capacity is 128,000,000,000 gallons. From Ashokan the water goes through the Catskill Aqueduct 75 miles to the Kensico Reservoir. This reservoir stores 29,000,000,000 gallons. Its function is to insure the continuity of the supply to New York if the aqueduct between Ashokan and Kensico is put out of service by accident or otherwise. The aqueduct continues 15 miles to Hill View equalizing reservoir, just outside the city line. After passing through this reservoir, the water enters the City Tunnel, 18 miles in length, 200 to 750 feet below the ground surface. The water is taken from the tunnel into the distributing pipe system through 22 shafts. From the terminal shaft in Brooklyn, a steel pipe extends 5 miles northeasterly, and another line crosses the harbor entrance and ends at a distributing reservoir on Staten Island.

No power development is included in the project.

The yield of the watershed directly tributary to Ashokan Reservoir is 250,000,000 gallons daily, but the supply is to be increased by the diversion of 250,000,000 gallons daily additional of water from the adjacent Schoharie watershed, and therefore the aqueduct was built to carry 500,000,000 gallons daily. The Schoharie development, comprising a great reservoir and a tunnel 16.7 miles in length, is to be begun shortly, and will require eight years' time for construction.

The aqueduct consists of—

- 55 miles of cut-and-cover aqueduct, 17' x 17'-6".
- 14 " " grade tunnels, 13'-4" x 17'.
- 17 " " pressure tunnels, generally 14' in diameter.
- 6 " " steel pressure pipe siphons.

Total 92 miles of aqueduct from Ashokan to Hill View Reservoir.

- 18 miles of "City Tunnel," a pressure tunnel 15' to 11' in diameter
- 14 " " steel and cast iron pipe, 36" to 66" in diameter
leading from the end of the City Tunnel.

Preliminary Work and Progress of Construction

The first report of the series which led up to the adoption of the Catskill project was made in 1897. Between 1897 and 1905 a great deal of thought was given to the planning of this development by some of the most eminent engi-

neers in America. In August, 1905, the present Chief Engineer, J. Waldo Smith, began his duties. In October, 1905, the report of the Board of Water Supply Commissioners, recommending the development, was submitted to and approved by the Board of Estimate and Apportionment, and in May, 1906, the approval of the State authorities was obtained. Shortly after this time the detail surveys, experimental work to determine the best types of construction for various features of the work, exploratory borings and shafts, design of structures, preparation of specifications, and purchase of real estate were begun. This "preliminary work" extended almost to the end of the construction period, as the experience gained on work in progress was taken into account as bearing on work not yet begun.

The program of construction was laid out as closely as possible so as to bring all parts of the work to completion at the same time. Work on the first contract was begun in June, 1907, and 1911 was the year of maximum expenditure (\$25,949,000), but the city tunnel was only commenced in 1911. The first Catskill water was delivered into the distribution pipes of New York City December 27, 1915.

The work described is now nearly completed, at a cost of over \$136,000,000, divided approximately as follows:

	Amount.	Per Cent of Total.
General administration	\$ 1,500,000	1.
Police Bureau	2,000,000	1.5
Engineering Bureau—		
Salaries, supplies and equipment.....	13,500,000	10.
Real estate and taxes.....	19,000,000	14.
Contract payments	100,000,000	73.5
	<hr/>	<hr/>
	\$136,000,000	100.

The annual disbursements are shown by the upper diagram on Exhibit "M."

The construction of the Schoharie reservoir and tunnel will cost \$26,000,000, raising the total to \$162,000,000.

These figures do not include interest during construction.

Organization

The Board of Water Supply consists of three commissioners appointed by the Mayor. It has had general supervision over the entire Catskill project, from the inception of the work to the present time. Its forces are divided into Administration, Real Estate, Police, Claims and Engineering Bureaus. In the first four bureaus are the secretary, the auditor, the chief clerk, the examiner of real estate, taxes, and legislation, the superintendent of Board of Water Supply Police, and the chief of the Bureau of Claims. The Engineering Bureau is composed of five departments: The Headquarters Department, in which the mapping, designing, preparation of specifications, etc., were carried out; and four departments each of which embraces a main division of the construction work. A department engineer is in general charge of all work in his department, which is subdivided into divisions and sections.

The engineering organization is shown diagrammatically on Exhibit "N," attached, and the fluctuation of the engineering force on Exhibit "O."

The Board exercised strict sanitary control over the contractors' camps, enforcing its regulations by means of its Police Bureau, which was also charged with the duty of maintaining order in the camps and on the work and protecting the inhabitants of the surrounding country against any bad characters who might be employed. The necessity for such control is seen from the fact that some of the camps assumed the proportions of good-sized towns. That at the Ashokan reservoir had a maximum population of 4500, of whom 3000 were employed on the work. The camp at Kensico dam had accommodations for 1200 persons.

The maximum number of men in the Board of Water Supply organization and the number employed at present are shown in the following table:

BOARD OF WATER SUPPLY FORCES

	Feb. 1, 1916	Maximum
Commissioners	3	3
Administration, Real Estate and Claims Bureaus.....	43	66
Police Bureau	70	387
Engineering Bureau—		
Chief Engineer and staff	11	13
Headquarters Department	124	260
Reservoir Department	148	236
Northern Aqueduct Department	67	630
Southern Aqueduct Department	113	318
City Aqueduct Department	110	209
Total, Engineering Bureau	573	
Total, Board of Water Supply	689	
Engineering Bureau; maximum force at any one time... ..		1,348

The greatest number of men included in the contractors' forces on active field work at any one time was 17,243.

The variation in the forces from the beginning of the work to the middle of 1915 is shown by the lower diagram on Exhibit "M."

THE HETCH HETCHY DEVELOPMENT

Like the two great engineering works already described, the Hetch Hetchy water supply project for San Francisco has been years in taking definite form. Unlike them, however, it has had to contend with strong opposition from powerful interests, both within and without the city whose growth is to be made possible by this vitally necessary addition to its resources.

The Progressive Development of San Francisco's Water Plans

When the present charter of San Francisco was framed, provisions were incorporated looking toward municipal ownership of the water supply. The charter went into effect in 1900 and in that year, by direction of the Board of Supervisors, the City Engineer began an investigation of "available sources" of water supply. It was decided that the Tuolumne River presented the most

advantageous possibilities, and in 1901 and 1902 surveys, studies and cost estimates were made, the results of which were embodied in a report by the City Engineer, C. E. Grunsky, dated July 28, 1902, presenting plans and estimates for a water supply system using Hetch Hetchy Valley as a reservoir site, with Lake Eleanor as a reserve for the future. The system was planned for an initial development of 60,000,000 gallons daily, capable of increase to 160,000,000 gallons daily. The aqueduct to San Francisco was to consist of 28 miles of open canal, 13 miles of tunnel, and a double line of 48-inch pipe 141 miles long, the total length of aqueduct being 182 miles. The water was to flow by gravity to the west side of the San Joaquin Valley, and was then to be pumped over the Coast Range by means of the power generated in the Sierra water drops. No power was available for other uses, and furthermore a large steam auxiliary was necessary to insure continuity of service in case the supply of electric power was interrupted.

In 1908 a revised plan was submitted by City Engineer Marsden Manson for an immediate development of 60,000,000 gallons daily and ultimate increase to 200,000,000 gallons daily. The essential difference from the Grunsky plan was the utilization of Lake Eleanor first, due to U. S. government restrictions in the Garfield permit, and Hetch Hetchy later. Mr. Manson afterward made several important changes in the scheme, increasing its ultimate capacity and power possibilities, so that in 1911 its principal features were as follows:

Lake Eleanor reservoir to be developed first, with a portion of the flood waters of Cherry Creek diverted into it; Hetch Hetchy to be developed later.

Main aqueduct to consist of:

- 27 miles of cut-and-cover conduit, capacity 300,000,000 gallons daily (part 365,000,000 gallons daily for the sake of increasing power).
- 30 miles of tunnel, same capacity as canal.
- 124 miles of double pipe line, each pipe 50 inches in diameter; capacity of the two pipes, 60,000,000 gallons daily.

181 miles total length of aqueduct.

40,000 horsepower to be developed and a large part of this power used for pumping, as in the Grunsky plan.

From 1908 to 1912 surveys were made for the canal lines, but difficulties with governmental authorities, due to private corporate interests persistently opposing the municipal enterprise, were so great that no progress towards actual construction was made. No similar interference was encountered in the Los Angeles and New York projects.

In 1910 John R. Freeman, a distinguished hydraulic engineer with broad experience, was engaged as consulting engineer by the City to make new plans and formulate a report which should summarize and supplement all knowledge already gathered pertaining to the extension of the City's water supply and also fortify the presentation of the City's application for the Hetch Hetchy grant. The plan presented in this report, dated July 14, 1912, providing for an ultimate supply of 400 million gallons per day from the Tuolumne watershed, is in its essentials the same as that on which work is now being carried forward, with certain necessary modifications due in part to the restrictions

of the congressional grant (known as the "Raker Bill") and in part to more mature study of the engineering and economic problems involved. The rights in the Hetch Hetchy and other public lands desired by the City were at last granted by act of Congress in December, 1913.

The plan as now proposed is shown by the maps and profile, Exhibits "A," "B" and "C," attached. The Hetch Hetchy will be the first reservoir site utilized, and the Lake Eleanor and Cherry Valley dams will be built later, as the necessity for increasing the water supply beyond the capacity of the Hetch Hetchy watershed arises. The aqueduct in the initial development will consist of 88 miles of pipe five to five and one-half feet in diameter, and 66 miles of tunnels ten to ten and one-half feet in diameter, a total length of 154 miles to the county line of San Francisco. After the first 19 miles of aqueduct from Early Intake is completed, the water will be dropped 1300 feet through an electric generating station at Moccasin Creek, where an average of 66,000 horsepower will be available. An ultimate consumption in the San Francisco Bay region of 400,000,000 gallons daily from this source is contemplated, and the aqueduct tunnel above the power house is designed for this quantity, so that the full amount of water may be diverted and used in the power house at once, thereby safeguarding the City's water rights and giving the City a marketable asset at an early stage of development. Below the power house, the tunnels from Moccasin Creek to the east foothills of the San Joaquin Valley are at present designed for 200,000,000 gallons daily, as the full quantity will not be required by the City for many years and as the saving in first cost and interest will greatly exceed the cost of driving a second parallel tunnel when it becomes necessary to do so at a later date. The tunnels in the Coast Range have been designed of the size specified for the same reason. The San Joaquin Valley pipe and the pipe from Irvington to San Francisco is made of only 60,000,000 gallons daily capacity, also to save initial cost and interest on premature investments.

The present scheme differs from the Grunsky and Manson plans principally in that the whole project is considered on very much broader lines, considering the future needs of a great metropolis and in accordance with the most modern developments of water supply engineering, and with all possible consideration for the ultimate development, not only of San Francisco, but also of the surrounding region whose growth and welfare are inseparably bound up with that of San Francisco. The advances in this branch of engineering in the last ten years have been very marked, and the City is getting the benefit of the experience of other large water supply projects developed in the past 15 years by our larger American cities.

The principal physical difference is that the grade-line conduits following the canyon walls of the Sierra Nevada, and much of the steel pipe in the San Joaquin Valley foothills and the Coast Range, as planned by Mr. Grunsky and Mr. Manson, are replaced in the present plan by permanent tunnels which also shorten the total mileage. A great part of the power generated under the older plans would have been consumed in pumping the water over the Coast Range, while the present plan develops the greatest economy by taking the water from its source to the receiving reservoir in San Francisco

entirely by gravity, leaving all of the power developed in transit available for other uses and entirely eliminating the operating costs of pumping. While these tunnels are more expensive to construct in the first place, the greater outlay is justified by the increased reliability of service, decreased maintenance charges, and increased power product.

The Freeman plan of 1912 called for all tunnels to be built at once for 400,000,000 gallons daily capacity; the San Joaquin Valley pipe line for 240,000,000 gallons daily, and the pipe line from Irvington to San Francisco for 50,000,000 to 100,000,000 gallons daily. In the interests of economy and due to the restrictions in utilization of irrigation waters in the Raker Bill, the size of initial installation has been modified as already described.

Summary of Work Already Accomplished

The preliminary work already done has been described in detail in the various annual reports of the City Engineer and in Exhibit "F" of this report. The extent of these activities has been limited only by the small amount of funds heretofore available. Lands and rights of way for reservoirs, aqueducts, power development and railroad purposes have been secured by application to the government authorities or by purchase from private parties; stream gagings have been kept up and new stations established; water rights have been maintained; railroad and aqueduct surveys have been made; roads and trails have been built; the clearing of the Hetch Hetchy reservoir site and the construction of the tunnel to divert the river past the dam site are in progress; and work has commenced on the railroad to haul materials and supplies to the various centers of activity from the Sierra foothills to Hetch Hetchy.

Program of Development

Before active work on permanent construction can be started, it remains to finish the reservoir clearing; complete and equip the railroad; complete the diversion tunnel and build a diversion dam; build additional roads and construction camps; construct a complete hydro-electric power system for construction purposes; and complete the designs for the permanent structures.

In proportion to the relative costs of the two projects, much more preliminary work has been required on the Hetch Hetchy than on the Catskill development because of the fact that the entire Catskill line lies in a settled region of low elevation, accessible everywhere by means of previously existing railroads and wagon roads, while the City's reservoir sites and much of the aqueduct line are in rough mountain regions inaccessible except by rough trails, almost uninhabited, remote from the railroad, and with few wagon roads.

It is estimated that, including the preliminary work yet to be accomplished, eight years will be required for the complete construction of the Hetch Hetchy system.

It is considered very important that the Moccasin Creek power plant be put in operation as early as possible in order to put the City's water to actual use. The work on the dam and the aqueduct above Moccasin Creek will

therefore be started as soon as the railroad is available to haul construction materials and supplies, and rushed to completion. In the meantime, exploratory work and studies for the location and design of the Sierra tunnel west of Moccasin Creek, the San Joaquin Valley pipe line, the Coast Range tunnel and the pipe line from Irvington to San Francisco will be carried on, and the necessary rights of way for these sections of the aqueduct will be acquired as soon as they have been definitely located. Actual construction on the Coast Range tunnel, which, as regards time of completion, is the controlling feature of the group just enumerated, will begin as soon as proper location studies are made, rights of way obtained and sufficient funds made available to carry it on in addition to the work in the Sierras. The dominant feature of our development plan so far has been to underwrite and absolutely secure our mountain rights against all kinds of predatory trespassers who have been endeavoring to encroach on and obstruct the City's developments in the high Sierras.

The time at which the City will be able to begin the generation of power at Moccasin Creek is governed by the time necessary to complete the longest single section of the nineteen-mile tunnel aqueduct above the power house, namely, the section extending from the point of diversion on the main Tuolumne River (Early Intake) to the South Fork crossing, a distance of 23,700 feet ($4\frac{1}{2}$ miles), where all work will be done from the two portals, as the tunnel grade is so far below the ground surface as to prohibit the sinking of shafts to secure additional working faces.

The Elizabeth Lake tunnel of the Los Angeles Aqueduct, as previously noted, is 25,000 feet in length and was worked from four headings. Nearly six years' time was required for its construction. However, unstable and water-bearing rock caused much trouble there. It is thought that five years will suffice for the Early Intake-South Fork tunnel. Although only two headings can be used, the rock is hard, the formation apparently uniform, and little trouble from water is to be expected.

The dam will probably be completed a year earlier than the tunnel, if both are started at once, but this margin is not large enough to warrant delaying the dam and besides there is the further desirability of having stored waters accumulated for a year in the Hetch Hetchy reservoir.

The construction of the Moccasin Creek power plant should be started two years before the estimated time of completion of the tunnel.

The Coast Range tunnel will be much more difficult to construct than that in the Sierra. Very careful geological investigation will be necessary before definitely locating the line, as large quantities of water and much unstable ground will be encountered. The greatest distance between shafts will be about three miles. A six-year construction period is allowed.

Exhibit "G" shows in tabular form the work already done from the inception of the Hetch Hetchy project, and the program for future work, so far as it is possible to lay out a definite plan at this time, and assuming that the work will not be hampered by financial or other limitations. This schedule shows the Moccasin Creek power plant ready for service at the end of 1921

and the entire system ready to deliver water to San Francisco at the end of 1923.

No consideration is given here to the City distributing system, as it is expected that by 1923 the properties of the Spring Valley Water Company will have been acquired.

Organization of Engineering Force

The remarks on this subject already quoted from the report of the consulting engineers on the Los Angeles Aqueduct (pages 3, 4 and 5) apply with equal force here.

A tentative organization diagram for the Hetch Hetchy Water Supply engineering force is attached as Exhibit "H."

HETCH HETCHY DEVELOPMENT PROGRAM FOR 1916

During the present year the chief works contemplated are the construction of the Hetch Hetchy Railroad, for which the contract has already been awarded; the completion of the diversion tunnel and diversion dam; preparation of the foundations for the main Hetch Hetchy Dam; preparation for the construction of a temporary power plant to supply electric current for the construction operations at the dam site; exploration borings by diamond drilling to determine the character of the formation through which the aqueduct tunnels will pass; the completion of the contract for clearing the reservoir; the continuation of the aqueduct tunnel from Early Intake toward South Fork; additional road and trail construction around Hetch Hetchy reservoir and the continuation of hydrographic, meteorological and survey work as well as the protection of the City's water rights in and adjacent to the Valley, including surveys, location and purchase of aqueduct right of way across San Joaquin Valley.

It is deemed inadvisable to undertake any of the other heavy construction on this project until the completion of the railroad line. In his report of February 17, 1915, the City Engineer submitted the figures of cost for transportation by rail as compared with auto truck haul. The cost of transporting 225,000 tons of material by motor truck was therein estimated at \$3,095,000, and the cost of hauling the same amount by railway, \$2,010,000, leaving a balance in favor of railroad haul amounting to \$1,085,000. In view of these figures, it is planned to defer whatever construction requires considerable haul of material until the railroad has been completed. Not only is the rail haul of cement more economic on a per ton basis, but also it is a most difficult undertaking to control the economic handling by truck of cement in sacks, some of which will be damaged in transit and leave room for endless controversies.

Lower Cherry Power Development for Construction Purposes

A large amount of power will be required for operating the machinery of the various construction plants at the dam site and along the tunnel aqueduct line.

Electric power is greatly to be preferred, and it is proposed to develop this power by diverting water from Cherry River, leading it through a canal to a point near Early Intake, and dropping it through a temporary power plant. A high tension transmission line, 12 miles in length, will connect this plant with the dam site and another line, 20 miles in length, will follow along the aqueduct line as far as Moccasin Creek, with a sub-station at each portal, shaft and adit of the tunnel aqueduct.

The canal will have a capacity of 200 cubic feet per second, and will be a permanent structure, as it is intended that after the construction period is over it shall remain in service for the purpose of making the water of Cherry Creek tributary to the tunnel aqueduct. This early applied use of the City's water rights on Eleanor and Cherry Creeks will obviate any possibility of successful future interference by enterprising speculators seeking to gain a foothold in that region. The development of power at this point will therefore serve a double purpose in sealing the gates against future intruders, but the value of the power output for construction use alone will justify the expense.

It is essential, of course, that the power plant should be ready to furnish power at the commencement of operations on the dam and tunnel. It will therefore be necessary to begin work on the hydraulic development as early as possible.

The work which should be completed on the temporary power plant during the present calendar year is as follows:

1. *Storage Dam* at Lake Eleanor: To carry the plant through the low water season, it is necessary to store water at Lake Eleanor. A suitable site for a low and inexpensive dam exists.
2. *Diversion Dam* on Cherry River: To divert the water of Cherry River (which includes the combined flow of Cherry and Eleanor Creeks) into the canal.
3. *Canal*: Conveying water from the point of diversion to the power drop at Early Intake.
4. *Power House*: Excavation of site.

The building and equipment of the power plant, and the penstock pipe supplying it, can be accomplished in a short time, and as it involves the transportation of considerable material and equipment, it will be deferred until the Spring of 1917, when the City's railroad will be in operation.

It is highly important, however, that the dams and the canal shall be constructed during the present calendar year. If delayed, power cannot be furnished as early as it will be needed. Also, by having these structures completed before the end of this year, we gain the additional advantage that before being put in service they will have had the benefit of several months in which to settle and season. The weak spots which are always found in a ditch in soft ground will have developed and been repaired, thus insuring the plant against interruption of service due to breaks along the canal line.

The cost of the construction work to be undertaken and completed during the calendar year 1916, as described above, together with the roads and trails necessary to make all portions of the work readily accessible, is estimated at

\$120,000. As this work is in large measure necessitated for the maintenance of our water rights in Cherry and Eleanor Creeks, this amount is divided in Exhibit "J", \$20,000 of it being charged directly to "Water Rights and Protective Work".

Construction at Hetch Hetchy Dam Site

As soon as the flow waters of the river subside to sufficient extent to allow of the construction of the diversion dam across the channel, this work will be undertaken. It is estimated that this structure will be completed by September 15, 1916, and the river diverted past the site of the main dam, the preparation of the foundations for which will then be immediately begun.

It is estimated that the total stripping on the main dam site will be approximately 32,000 cubic yards, of which about 20,000 cubic yards will be on the lower part of the foundations (below elevation 3510). Roughly, 13,000 cubic yards of the above mentioned 20,000 cubic yards will be solid rock excavation (to elevation 3560 \pm):

It will be more economical to strip the upper parts of the dam site as the main dam is constructed, and for the present season only the lower part will probably be attacked. The approximate cost will be as follows:

For installation of additional derrick.....	\$ 2,750
13,000 cubic yards of sand and boulders @ 45c.....	5,850
7,000 cubic yards of rock (removed by hand picking—no heavy shooting allowed) @ \$2.70 per cubic yard.....	18,900
It will probably be necessary to investigate the foundations by drilling or drifting, or both, but this cannot be determined until the bedrock is cleaned off. An allowance is made here for 2,000 lineal feet of hole grouted at \$1.50.....	
	3,000
Cut-off wall at lower end of dam site.....	8,500

Total for low foundation work.....\$39,000

In addition to the above, it will probably be desirable to clear the channel below the dam site this year. This cost will be about \$13,000.

Miscellaneous Work

Proceeding along the aqueduct westerly from the Early Intake, it is proposed to bore eighteen diamond drill holes approximately a mile apart varying in depth from 40' to 928'. Six of these holes averaging 650' in depth will be west of the westerly boundary of the Stanislaus National Forest and the remainder will be between this boundary and the Early Intake.

For the information of this Department, it is essential that accurate records covering a long period of years be kept of the hydrography of the Tuolumne and its tributaries. These will be continued by hydrographers assigned by the U. S. Geological Survey, working under the direction of the City Engineer.

Besides continuing the aqueduct tunnel westerly from Early Intake in order to protect the City's rights thereto, in accordance with provisions of San Francisco's Hetch Hetchy Grant, a new road will be constructed to the westerly portal of this tunnel on the South Fork of Tuolumne River.

Accident Insurance

So far, the City has been exceedingly fortunate in eliminating accidents by exercising the utmost precaution in all of its Hetch Hetchy construction. It is impossible, however, to predict that any work of this magnitude can be carried to completion without accidents, despite the utmost vigilance on the part of the engineers and inspectors. One fatality would consume more funds in indemnity than has been paid to the State Compensation Fund for insurance during the past six months. The advisability of continuing this insurance is therefore urged upon your Honorable Board. During the construction of the diversion tunnel the rate was higher than on any work which the City will perform during the coming year, and a material reduction in premium will therefore be made on all construction work undertaken since the enactment of the Workmen's Compensation Law. Contractors as well as municipalities figure in the cost of their construction work the additional expense of insuring their workmen.

Acquisition of Lands and Rights of Way

Provision should be made at this time for the acquisition of necessary rights of way through privately owned lands for the aqueduct tunnel, pipe lines and appurtenant structures all along the line from the high Sierra to the San Francisco Bay region. Such purchases can be made at lower prices at the outset of the project—as soon as the definite location has been decided on—than after work has been commenced on adjacent divisions. In particular, there is to be acquired a tract of 80 acres owned by Joseph Cavagnero on which to construct the Moccasin Creek power house and its appurtenant buildings and the re-regulating reservoir into which the water will be discharged after passing through the power house. This land will cost about \$10,000. The \$500,000 appropriation requested for these purposes includes provision for the acquisition of about 60 acres of lands in San Francisco for the Glen Park or San Miguel receiving reservoir.

Medical Service

In Exhibit "K", hereto attached, is recorded the gist of the agreement between the City of Los Angeles and the contractor to whom was deputized the work of providing hospital accommodations for employees of the Los Angeles aqueduct project. A similar arrangement by the City is suggested whereby the sum of 75c a month, or less, will be deducted from the wages of each City employee on this project, in consideration of which he will be provided with hospital attention and medicine in case of illness.

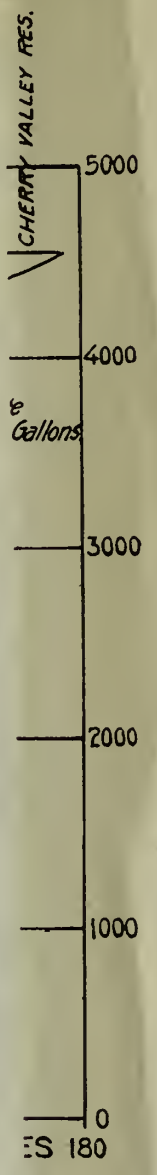
Hereto is also attached Exhibit "I", showing the condition of the Hetch Hetchy funds and appropriations to date; also Exhibit "J," wherein the amounts of money to be appropriated during the present year are set forth.

LIST OF EXHIBITS

- A. General Map of the Hetch Hetchy Water Supply.
- B. General Profile of the Hetch Hetchy Water Supply.
- C. Map of the Hetch Hetchy Railroad and Tunnel Aqueduct in the Sierra Nevada.
- D. Diagram Showing Average Daily Consumption of Water in San Francisco for each year from 1909 to 1915, inclusive.
- E. Population and Water Consumption of San Francisco from 1900 to 1915, and estimated increase from 1916 to 1935.
- F. Detail of Progress of Work in 1915.
- G. Expenditures on the Hetch Hetchy Water Supply from 1900 to 1916, and estimated Annual Expenditures to the end of the construction period.
- H. Tentative Organization of Engineering Force for the construction of the Hetch Hetchy Water Supply.
- I. Condition of Hetch Hetchy Appropriations, February 4, 1916.
- J. Appropriations Requested for Hetch Hetchy Water Supply Work to be executed from March to December, 1916.
- K. Medical Service and Accidents to Employees on the Los Angeles Aqueduct.
- L. Los Angeles Aqueduct: Organization of Engineering Force during construction period.
- M. Catskill Water Supply of the City of New York: Annual Expenditures; Fluctuation of Contractors' Forces.
- N. Catskill Water Supply of the City of New York; Engineering Bureau Organization.
- O. Catskill Water Supply of the City of New York: Fluctuations in Engineering Bureau Forces.



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Point Arena



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Vert. 1" = 1000 Feet

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EXHIBIT B



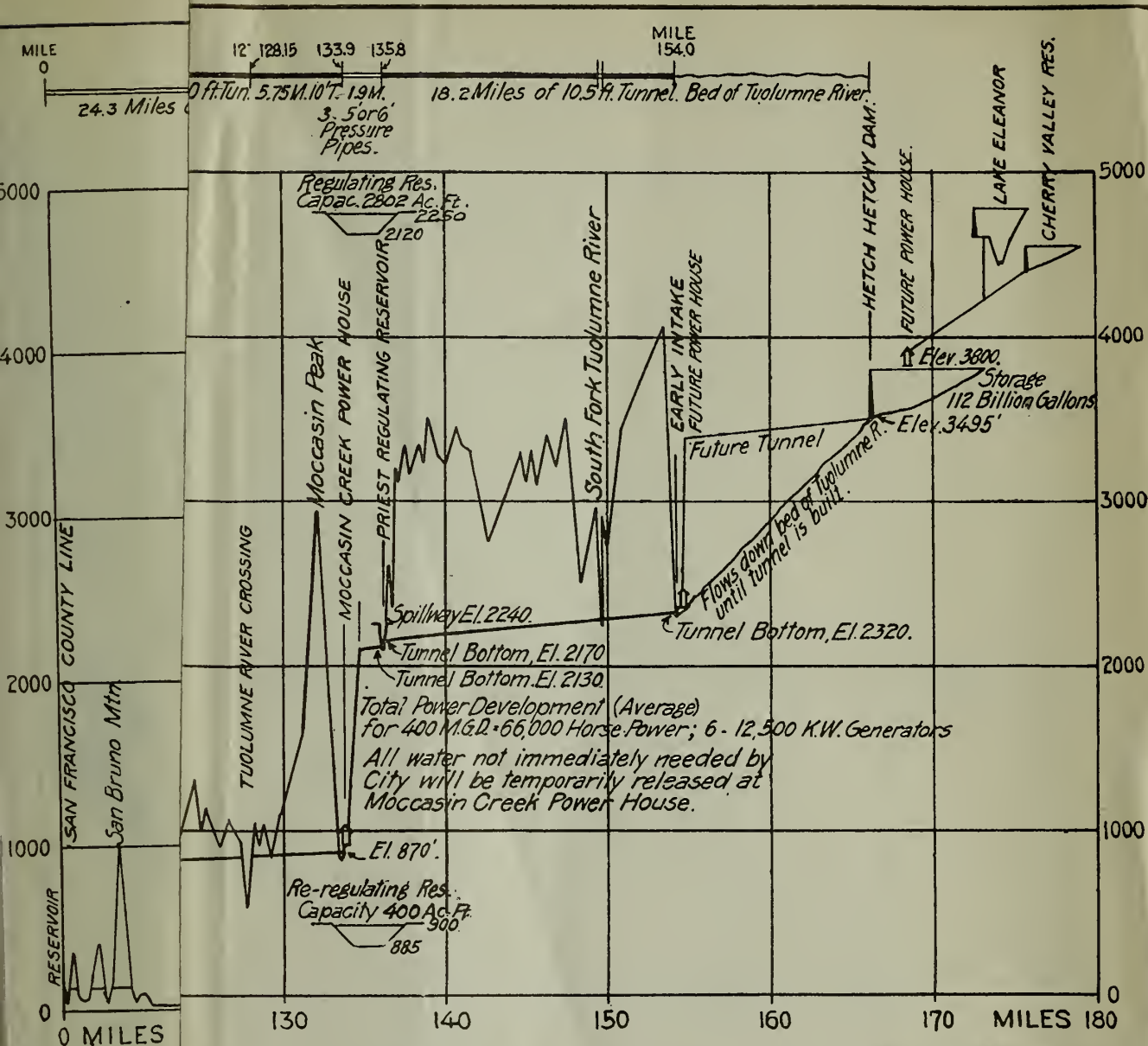
**HETCH HETCHY WATER SUPPLY
OF THE CITY AND COUNTY OF
SAN FRANCISCO, CALIFORNIA.**

**GENERAL MAP
HETCH HETCHY WATER SUPPLY
TO ACCOMPANY REPORT OF MINOR ENGINEER,
MARCH 1916.**

DEPARTMENT OF PUBLIC WORKS

APPROVED *W. W. O'Shaughnessy* CIVIL ENGINEER

EXHIBIT A



HETCH HETCHY WATER SUPPLY OF THE CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA.

GENERAL PROFILE

HETCH HETCHY WATER SUPPLY

TO ACCOMPANY REPORT OF M.M. O'SHAUGHNESSY, CITY ENGR.,

MARCH 1916.

DEPARTMENT OF PUBLIC WORKS

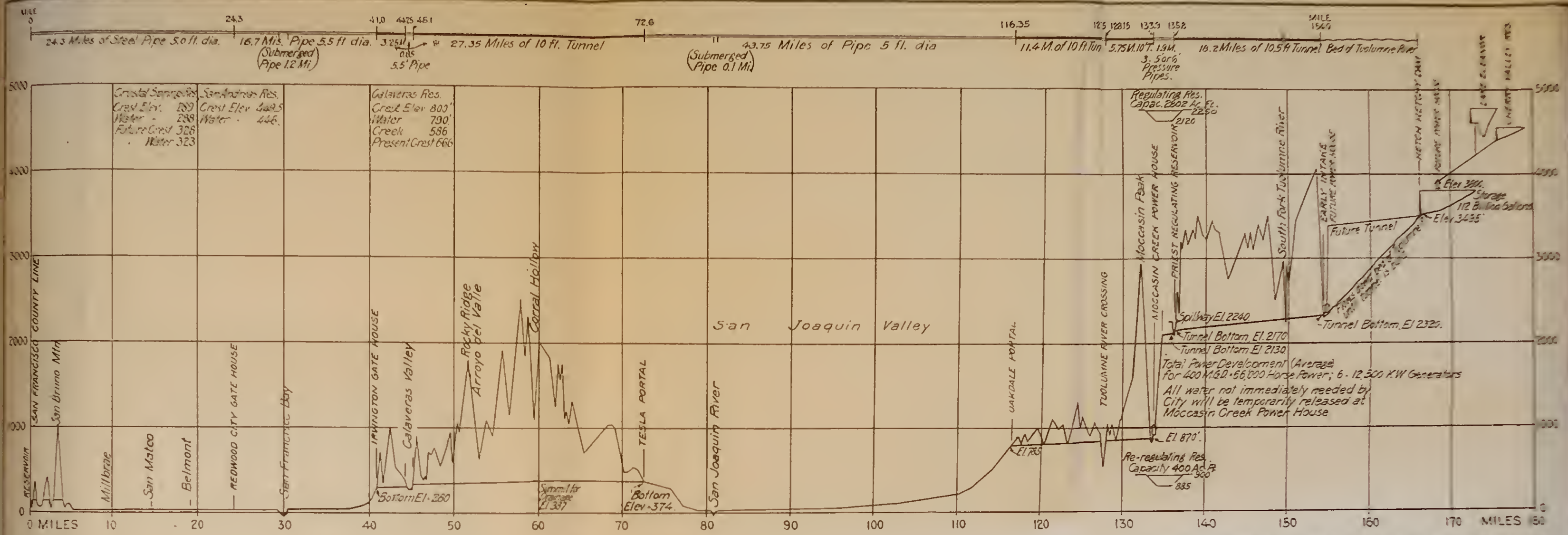
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Vert. 1" = 1000 Feet

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EXHIBIT B



HETCH HETCHY WATER SUPPLY
OF THE CITY AND COUNTY OF
SAN FRANCISCO, CALIFORNIA.

GENERAL PROFILE
HETCH HETCHY WATER SUPPLY
 TO ACCOMPANY REPORT OF M.M.O'SHAUGHNESSY, CITY ENG'G.

MARCH 1916.
DEPARTMENT OF PUBLIC WORKS

APPROVED *W.W. O'Shaughnessy* CITY ENGINEER

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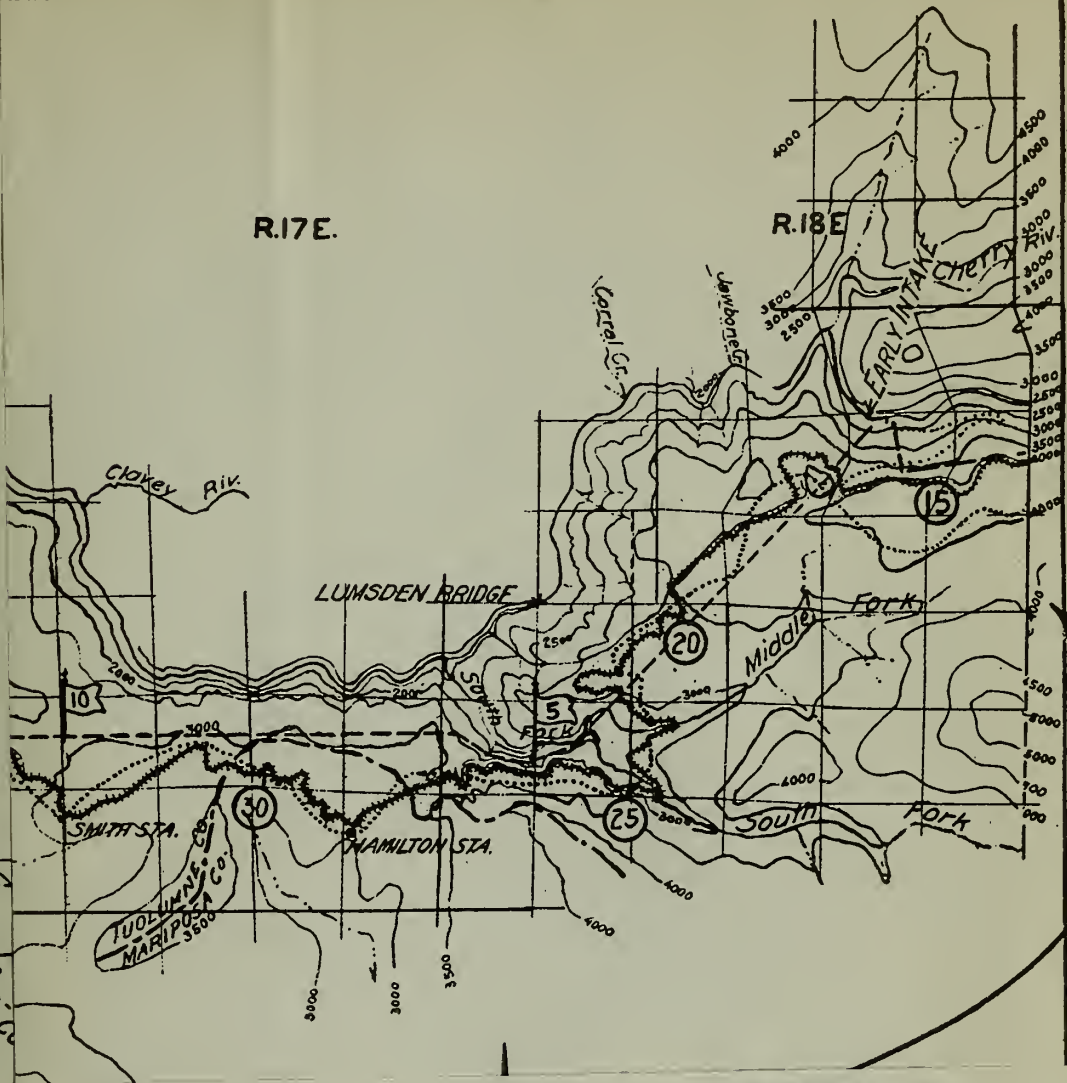
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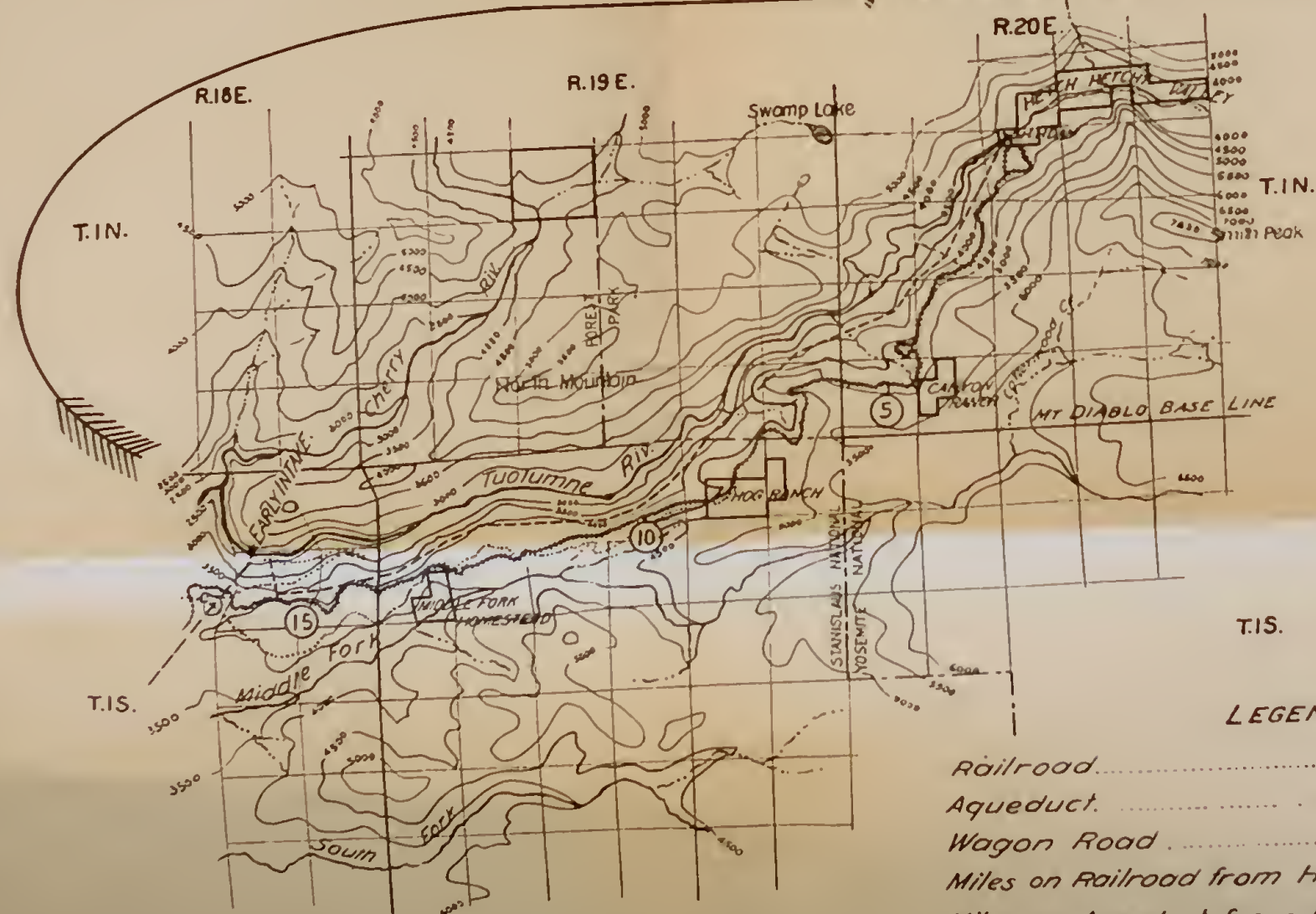
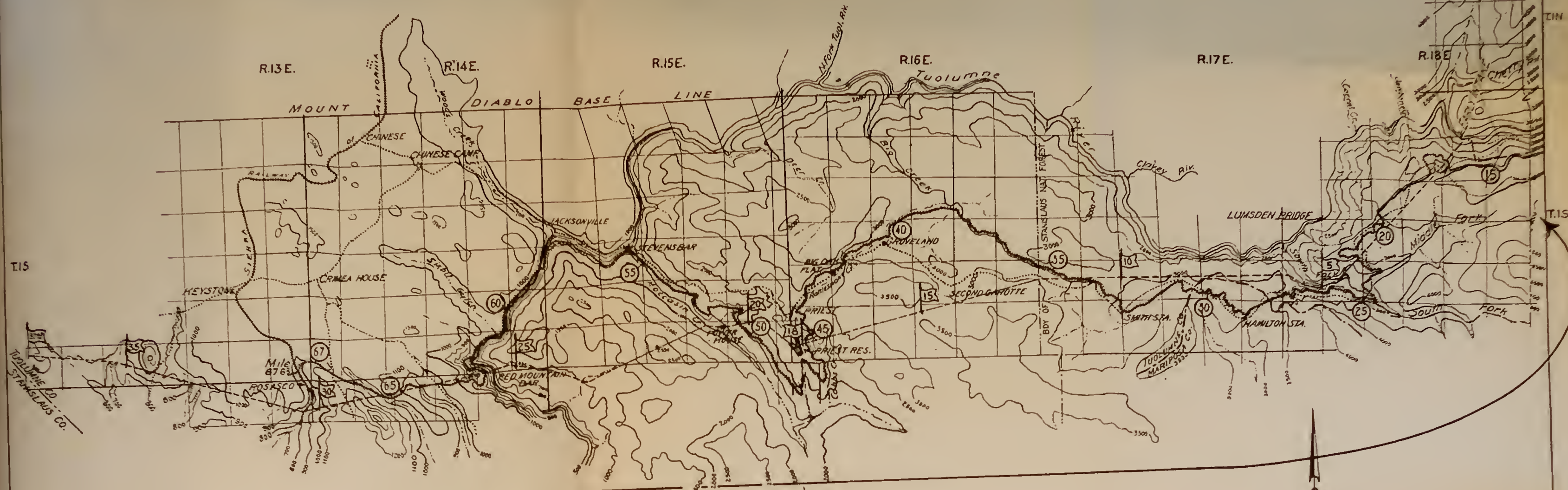


37 52
TULUMNE CO.
STANISLAUS CO.

838
MARCH 1916

MARCH, 1916.

TO ACCOMI



LEGEND:

- Railroad
- Aqueduct
- Wagon Road
- Miles on Railroad from Hetch Hetchy
- Miles on Aqueduct from Early Intake

**HETCH HETCHY WATER SUPPLY
OF THE CITY AND COUNTY OF
SAN FRANCISCO, CALIFORNIA.
HETCH HETCHY RAILROAD
AND
AQUEDUCT
IN
TUOLUMNE COUNTY**

DEPARTMENT OF PUBLIC WORKS
APPROVED *W. J. O'Shaughnessy* CITY ENGINEER

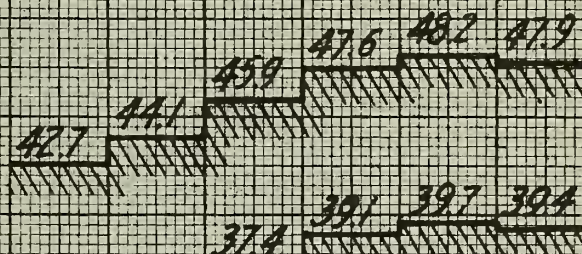
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AVERAGE DAILY CONSUMPTION
IN MILLIONS OF GALLONS

50
45
40
35
30
25
20
15
10
5
0

TOTAL WATER CONSUMPTION
FROM ALL SOURCES



WATER SUPPLY FROM
SPRING VALLEY SOURCE



WATER PUMPED FROM W

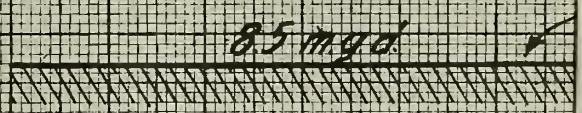
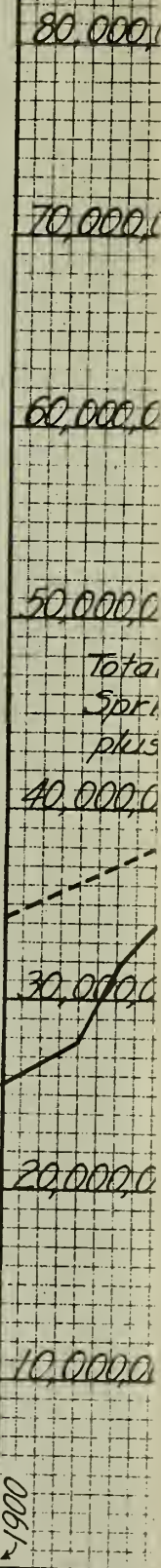


DIAGRAM SHOWING
AVERAGE DAILY CONSUMPTION
IN SAN FRANCISCO
FOR EACH YEAR FROM 1909 TO 1914

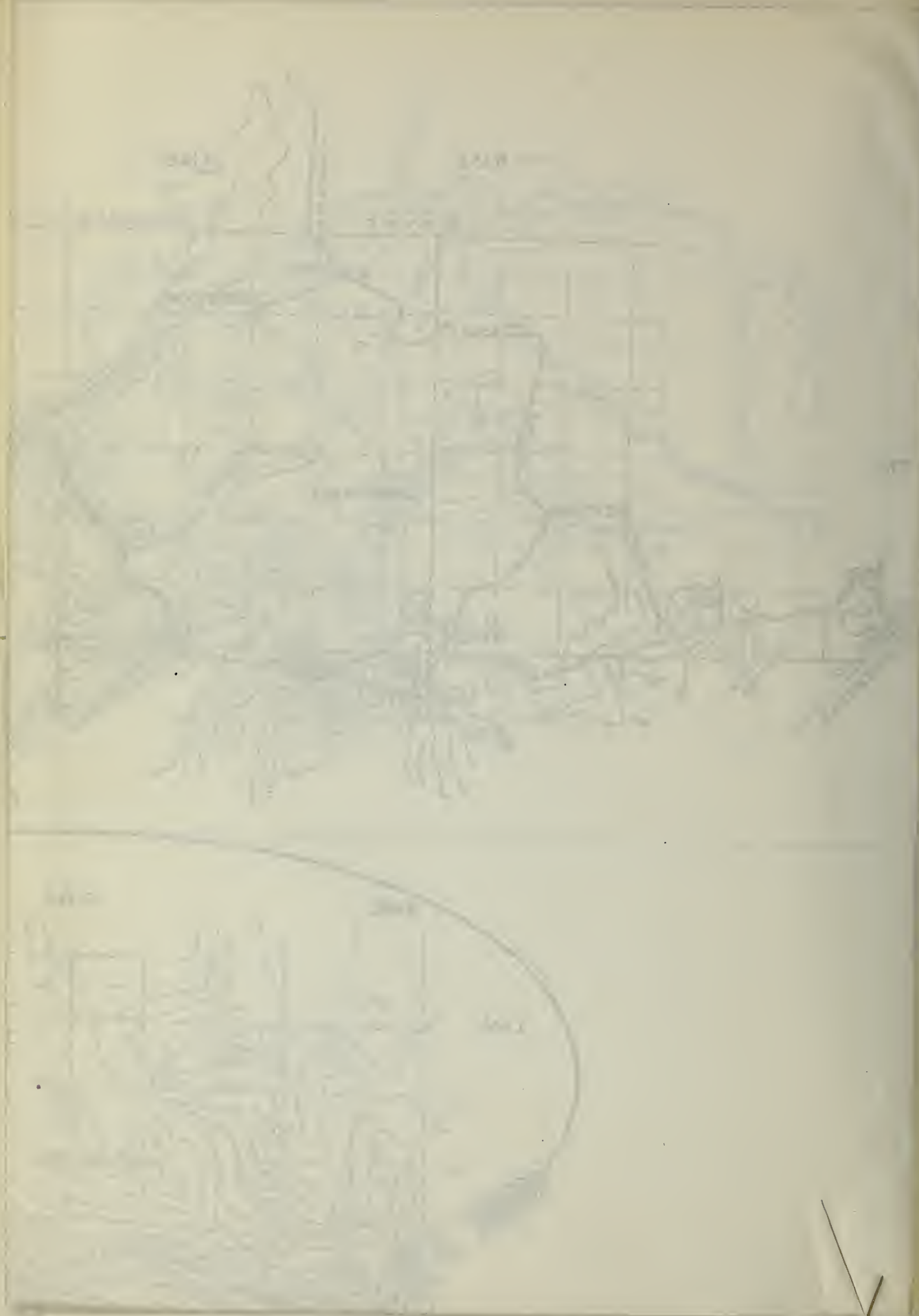
TO ACCOMPANY REPORT OF
M.M. O'SHAUGHNESSY, CITY ENG
MARCH, 1916.

DAILY CONSUMPTION OF WATER - GALLONS



POPULA

TO ACCOMI



AVERAGE DAILY CONSUMPTION
IN MILLIONS OF GALLONS

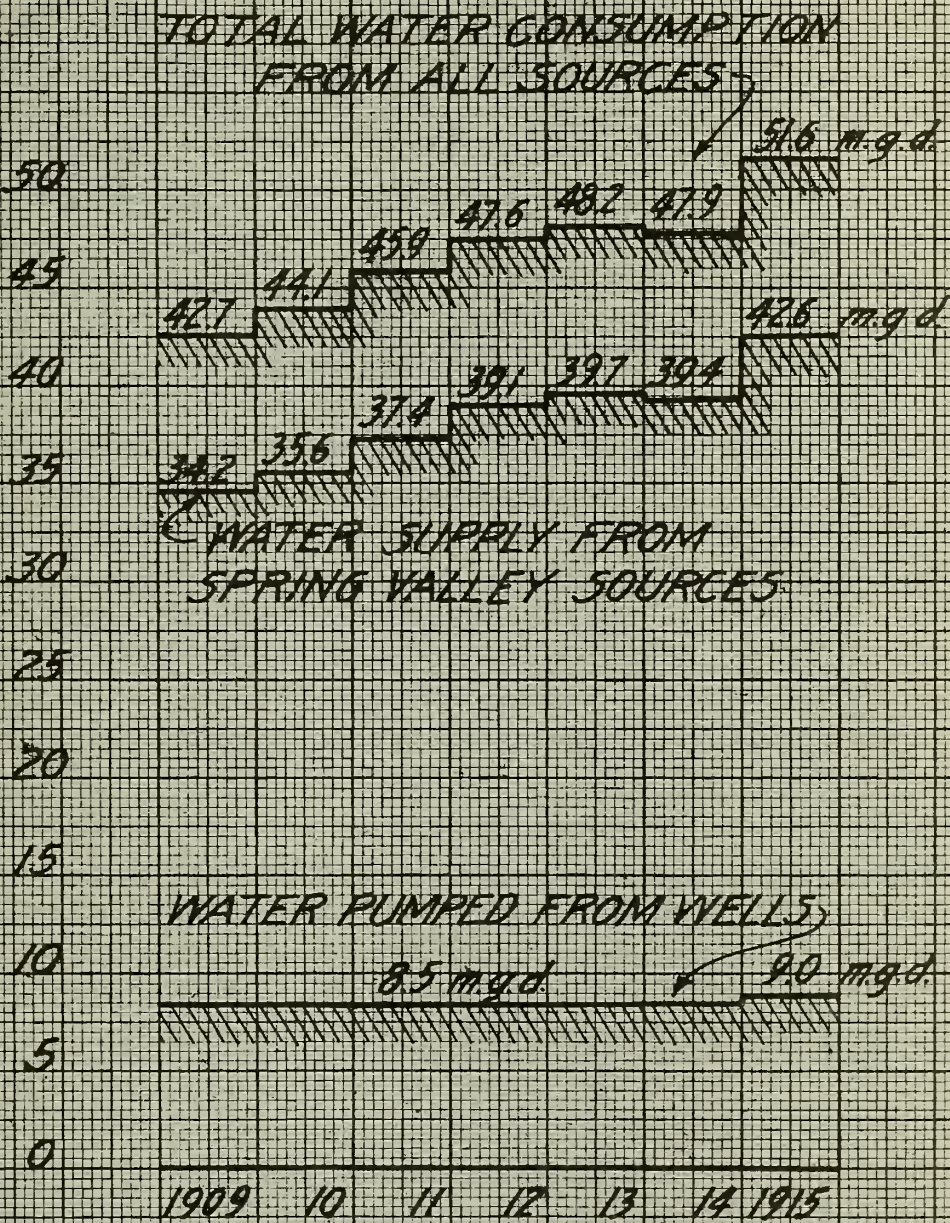
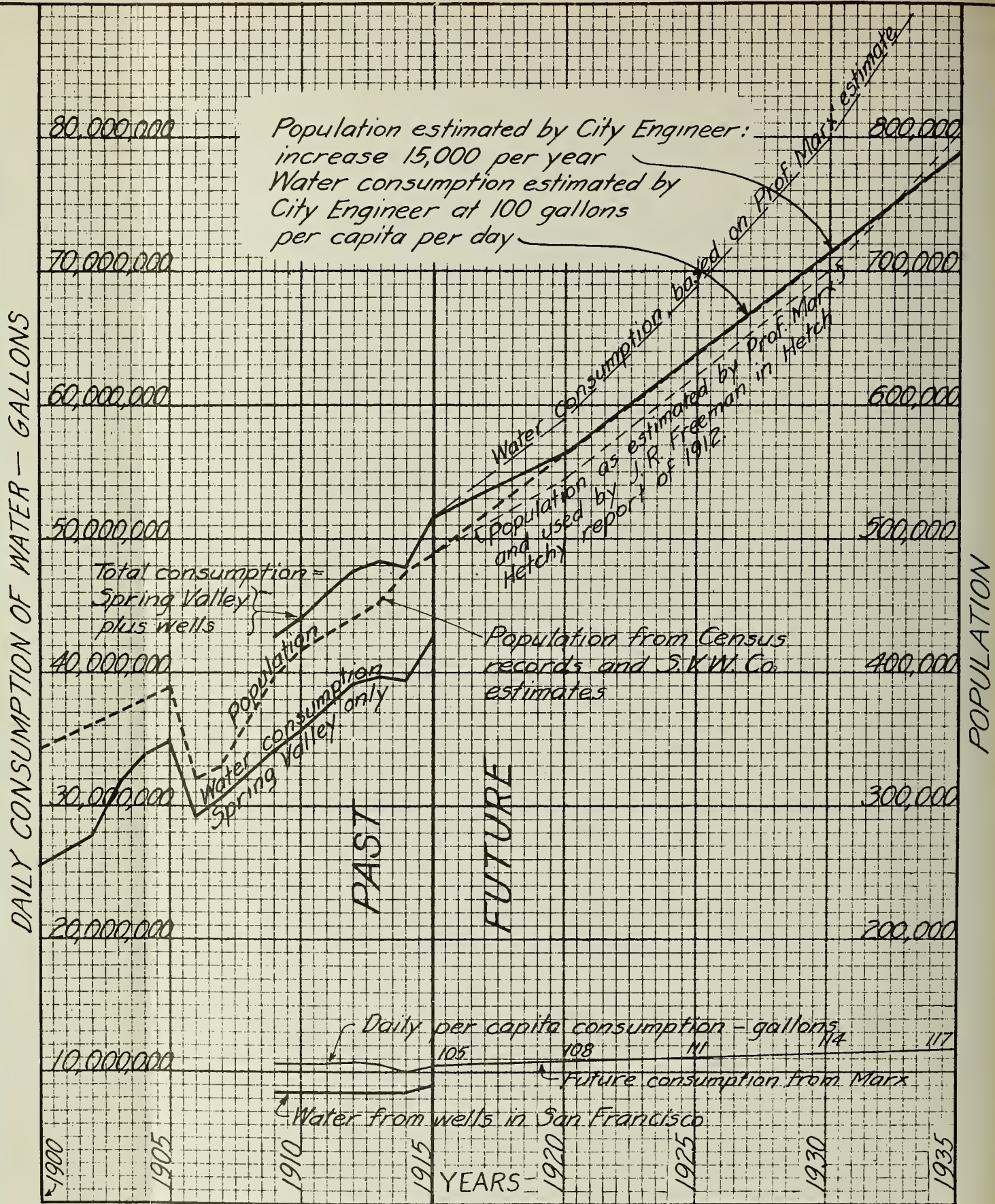


DIAGRAM SHOWING
AVERAGE DAILY CONSUMPTION OF WATER
IN SAN FRANCISCO
FOR EACH YEAR FROM 1909 TO 1915 INCLUSIVE

TO ACCOMPANY REPORT OF
M.M. O'SHAUGHNESSY CITY ENGINEER,
MARCH, 1916.

EXHIBIT D.



POPULATION AND WATER CONSUMPTION OF SAN FRANCISCO
FROM 1900 TO 1915, AND
ESTIMATED INCREASE TO 1935.

TO ACCOMPANY REPORT OF M. M. O'SHAUGHNESSY, CITY ENGINEER, MARCH, 1916.
EXHIBIT E.

EXHIBIT "F"

DETAIL OF WORK UNDER CONSTRUCTION

Since filing my last annual report of February, 1915, work has been done on the development of the Hetch Hetchy Water Supply and power system as follows:

WATER RIGHTS AND PROTECTIVE WORK

According to the provisions of San Francisco's Hetch Hetchy grant the development of the City's Sierra water supply "shall be prosecuted diligently and no cessation of such construction shall continue for a period of three consecutive years, and in the event that the Secretary of the Interior shall find and determine that there has not been diligent prosecution of the work or of some integral and essential part thereof, or that there has been a cessation of such construction for a period of three consecutive years, then he may declare forfeited all rights of the grantee herein as to that part of the works not constructed, and request the Attorney General, on behalf of the United States, to commence suit in the United States District Court for the Northern District of California for the purpose of procuring a judgment declaring all such rights to that part of the works not constructed to be forfeited to the United States".

Pursuant to a policy of active development, construction was started simultaneously at several locations in 1915, the extent of activity at each point being determined by the funds available from a restricted sale of 4½% bonds due to market conditions, and by the relative value of each unit in furthering the City's plans.

At the Early Intake, twelve miles below Hetch Hetchy dam site, water released from that reservoir site, and flowing along the natural bed of the river channel, will be diverted into pressure tunnel 10½ feet in diameter, which for some years to come will be the easterly terminal of the City's main aqueduct. This tunnel will pass beneath the mountain backbone on the south side of the Tuolumne River for a distance of 19 miles, to the Priest's Hill regulating reservoir near Moccasin Creek. The vicinity of the upstream intake portal has been excavated and the tunnel face started ready for power drills. The excavation of a bench in the slope above the river floods for the aqueduct leading from the Early Intake diversion dam site to the tunnel portal is also under construction, and in this portion of the aqueduct will be placed necessary sand screens and scouring chambers to automatically intercept any floating sand or debris, thereby preventing clogging of the aqueduct and dependent reservoirs.

A suspension foot bridge was built across the river at Early Intake to allow the men working on the tunnel to cross over to the construction camp, which will be built on the northerly bank of the river where advantage can be taken of whatever sunshine is available in this deep canyon for sanitary reasons.

Work on the Early Intake road, begun in 1914, was continuously prose-

cuted with a small force until the very heavy snowfall necessitated its discontinuance in December, 1915. This road is now approximately 80% completed. The work has just been resumed for this year.

The nine mile road from Hog Ranch to Hetch Hetchy dam site, constructed by the Utah Construction Company, under Contract No. 1, was surfaced in the spring of 1915, so as to put it in condition for the heavy wagon loads which were hauled for the installation of the sawmill, compressor, and other work.

Following the surveys of 1914, the application map for which was approved by the Secretary of the Interior on January 21, 1915, a road was constructed from Hetch Hetchy camp down into the floor of Hetch Hetchy Valley. This road has a length of .85 mile and was built on a 10% grade. It allows of access to Hetch Hetchy Valley by team or auto truck, which has been considered necessary as a construction adjunct to the main dam. The road was constructed entirely by day labor by City employees.

Trails were built from Hetch Hetchy camp down to and around the dam site and a road was built to allow of the hauling and installation of all plant, to be used in construction of not only the Diversion Tunnel, but also the Diversion and Main Dams.

A trail was begun from the main road between Colfax Gate and the Toll Bridge, leading toward the proposed aqueduct crossing on South Fork. This trail has not yet been completed.

In conjunction with the Forest Service and other interested parties, a bridge was built over the Middle Fork on the road between Hog Ranch and Sequoia. Before this bridge was built the road was impassable when the Middle Fork was at high stages, and it was then necessary to ford the river.

PERMANENT CAMP

Following the topographic survey of the Hetch Hetchy camp, studies and designs were made in the office for the main camp for housing the men to be engaged on the construction of the Hetch Hetchy Dam.

Late in June clearing of portions of the camp site was begun. Work was continuously prosecuted on the camp construction until the heavy fall of snow in December. The work was then practically discontinued, at the present time there being but a few men engaged thereon.

The construction of camp buildings at the Hetch Hetchy dam site was begun in September, 1915, the first building constructed being the dining room, 120 feet by 40 feet. This was followed by building of bunk houses and cement warehouse. There have been built also one 3-room cottage, a hospital, wood house, oil house, meat house, and other buildings. A water system with wooden tanks and 2-inch water mains has been completed, and roads around the camp have been undertaken.

DIVERSION TUNNEL

For the purpose of by-passing the stream flow of the Tuolumne River during the excavation of the foundations for the dam and the construction

of the dam proper, a tunnel was drifted at the dam site. This tunnel was commenced late in September. Owing to the difficulty of securing prompt delivery of the compressor plant, due to tardiness in plan approval by Interior Department officials, the work was begun by hand drilling. When the tunnel heading was well started, two crews were put on, working night and day, and the heading was drifted through on the 30th day of December.

The main tunnel is to be 20 feet in diameter. The completed heading is approximately the upper half of the whole tunnel. The excavation of the bench on the remaining half is now being carried on. The rock is a very hard grade of granite requiring no timbering and is a good indication of the nature of the excellent foundation of the main Hetch Hetchy Dam. A portion of the spoil has been saved for use in the concrete construction of the diversion dam.

DIVERSION DAM

Preparations were made to construct the diversion dam to divert the river flow into the diversion tunnel, above mentioned, thereby unwatering the main dam site. A bench was made for hoisting engine, the engine installed, and derrick parts and cable hauled in and put in place preparatory to storing sand from the river bed. Lumber for flume and form construction has been delivered on the ground from Canyon Ranch sawmill.

The delivery of the cement to be purchased under Contract No. 8, for the construction of this dam, was delayed by early rains and snows so that it was not possible to prosecute the dam construction this winter, as contemplated. As soon as the material is received on the ground, the work will be carried on and the river water diverted past the foundation of the main dam at the dam site.

The commencement of both the Diversion Tunnel and Diversion Dam was delayed from April till August—four months—due to lack of approval of plan program by the Assistant Secretary of the Interior. It is needless to state that delays of this nature prove a hardship and serious handicap to the City, where the fair weather season is so short, due to winter snows, etc.

TELEPHONE LINE

The City's telephone line from Groveland to Hog Ranch was extended as a single iron wire from Hog Ranch to Hetch Hetchy Camp. Some repairs and improvements in the old line were also made. The line is now in operation from Groveland to Hetch Hetchy dam site.

CANYON RANCH SAWMILL

A site for the sawmill at Canyon Ranch in the City's property owned in fee was selected in the spring and in April grading was begun thereon. This was followed by felling and hewing of timbers sufficient to construct the first part of the frame for the mill. The final timber work was made with timber sawed at the mill.

Sawmill machinery, purchased under Contract No. 2, was delivered at

Chinese and hauled to Canyon Ranch during June. The machinery was completely installed early in July and sawing was begun on July 21.

Great care was observed to preserve the natural forest appearance of Canyon Ranch, and not mar the scenic features of the National Park by the City's activities. One of the means used was to leave untouched a screen of trees immediately next to the railroad.

Sawing was continued until November, when, on account of the snow fall, the mill was shut down. About 1,200,000 feet B. M. were manufactured during the season, a portion of this being surfaced. A large portion of this lumber was hauled to Hetch Hetchy dam site for use in permanent camps, a portion was used at the sawmill in construction of frame for the mill, office, bunk houses, etc., and the remainder was piled for seasoning. The area on which the timber was cut at Canyon Ranch has been cleared, the slash and brush burnt in a satisfactory manner. During December the mill was housed in, engines, etc., covered, and everything put in good style to withstand the winter storms.

There is now remaining on Canyon Ranch about 800,000 feet B. M. of timber, which can be cut by the mill. In the floor of Hetch Hetchy Valley there are about 2,000,000 feet B. M. of logs suitable for saw timber.

DEFENSE AGAINST OPPOSITION WATER AND POWER CONCERNS

The Yosemite Power Company has pending before the Department of the Interior applications for rights on the Tuolumne River in the National Park and Forest Reserve, which conflict seriously with the development works as proposed by the City. A determined stand was made by this office against the United States Government approving the validity of these claims, hydro-graphic and other data was prepared and submitted to United States Government officials and studies made of the company's proposed hydro-electric power development. The City Engineer with the City Attorney and the Clerk of the Board of Supervisors left for Washington, D. C., on January 18, 1916, to oppose the claims of this company, which is controlled by the Hammond interests. The hearing of both sides was held before the Secretary of the Interior on January 26th, 27th, and 28th, and the objections presented by City officials taken under advisement by him. Little doubt is felt of a verdict favorable to the City, for in a similar proceeding in 1912, Ex-Secretary of Agriculture Wilson ejected the National Park Electric Company, another wildcat concern, from the National Forest at the request of the City under conditions which were practically identical with those obtaining in the present case.

CONTRACTS

The following contracts were operative during the past year:

Contract No. 1: "For Constructing Road from Hog Ranch to Hetch Hetchy Dam." This work was begun in August, 1914, and completed in February, 1915, by the Utah Construction Company, at a total contract price

of approximately \$180,000. 9.09 miles of 22-foot road-bed was graded. The maximum grade is 4% and the minimum radius of curvature 191 feet. The greater part of the material handled in grading was solid granite. The road-bed was later surfaced, as elsewhere noted in this report, and is now being utilized for the transportation of machinery, materials and men to and from Hetch Hetchy Valley. It will form a part of the road-bed for the railroad now being constructed under Contract No. 7. Previous to the construction of this road, the Hetch Hetchy Valley was accessible only by trail.

Contract No. 2: "For Furnishing Sawmill Machinery." Bids were received on April 14, 1915, and the contract was awarded on April 19, to the Eby Machinery Company, for the sum of \$4,975. Final payment was recommended on August 31, after a successful trial run of the machinery.

Contract No. 3: "For Furnishing Logging Engine." Bids were received on April 14, 1915, and the contract was awarded on April 28, to the Western Equipment Company, for \$2,950. Final payment was recommended on August 19, after a successful trial run of the logging engine.

Contract No. 4: "For Clearing Portion of Hetch Hetchy Reservoir Site." Bids were received on September 15, 1915, but were rejected (September 20) on account of irregularity in the lowest bid. The contract was re-advertised, bids being received on September 29th, and award was made to A. J. Reeder on October 1st, for the estimated sum of \$31,675, with a possible bonus of \$1,500. This work is still being prosecuted, with a force of nearly 150 men, and will probably be finished in the early spring. A large amount of cord wood and of saw logs will be turned over to the City as a result of the work done under this contract. It may prove advisable to move the sawmill from its present site to Hetch Hetchy Valley, when the sawing of the timber now standing on Canyon Ranch is completed.

Contract No. 5: "For Furnishing Air Compressing Plant and Drills." Proposals were received on September 8, 1915, and the contract awarded on September 15th, as follows:

Proposition No. 1—Boilers, to the Chicago Pneumatic Tool Company, for \$2,877.

Proposition No. 2—Air Compressor, to Ingersoll-Rand Company of California, for \$3,019.

Propositions Nos. 3, 4 and 5—For Drills, Receivers, Sharpener and Accessories, to Rix Compressed Air Drill Company, for \$4,431.50.

This machinery was delivered to Hetch Hetchy dam site in November. It has all been assembled and is almost ready for regular operation. Partial payments have been made.

Contract No. 6: "For Furnishing Hoisting Engine and Boiler." Proposals were received on October 8, 1915, and contract awarded on October 11th to A. L. Young Machinery Company for \$1,357. The engine was delivered at Hetch Hetchy dam site in November and installed, as noted under "Diversion Dam."

Contract No. 7: "For the Construction of the Hetch Hetchy Railroad." Specifications were prepared for this work and proposals received on October 28, 1915. The proposals were six in number, the lowest being that of F. Rolandi of this City for the estimated sum of \$1,543,080.74. This bid was accepted by the Board of Public Works on December 6, 1915. Owing to the difficulty of selling bonds to finance the contract, construction had not yet begun at the end of the year, although preliminary work was being carried on. Since January 1, 1916, however, bonds to the amount of \$1,250,000 have been sold to Blyth, Witter & Co., which assures the completion of this contract, and work has now been started.

This contract will include grading 58 miles of line, from Hog Ranch to Rosasco, furnishing all materials, and constructing a railroad over the total 67.63 miles, with necessary sidings and other accessories, from Rosasco to Hetch Hetchy dam site.

This Department gratefully acknowledges the co-operation of City Attorney Long for the effective work done in rapidly securing the railroad right of way, and other activities bearing on the legal phases of the project.

Contract No. 8: "For Furnishing Cement." Bids were received October 23rd, 1915, and contract awarded on October 26th to the Santa Cruz Portland Cement Company, for furnishing at Chinese Station 3,975 barrels of cement. The contract price was \$10,613.25. Delivery was begun immediately upon award of contract, but the early rainfall and snow interfered with the hauling to such an extent that the completion of delivery had to be deferred until the end of winter. At the present time there have been delivered at Chinese Station 2,350 barrels. This cement is to be used in the construction of the Diversion Dam, the preliminary work for which has already been done.

Contract No. 9: "For hauling cement from Chinese, a station on the Sierra Railway of California, Tuolumne County, to Hetch Hetchy Dam Site." Bids were received on November 5, 1915, and contract awarded on November 6th to Charles B. Dunham at \$23 per ton. Hauling was begun immediately upon award of contract and carried on intermittently, as rapidly as the weather and conditions of roads would permit. Hauling has now been discontinued, with some cement delivered at Hetch Hetchy Dam Site and some stored en route.

Stream Measurements

Hydrographic and meteorologic observations have been continued at Hetch Hetchy, Eleanor Creek and Cherry Creek. This work has been conducted by men assigned by the Water Resources branch of the United States Geological Survey, under the direction of the City Engineer.

The stream measurements on the Tuolumne River, near Hetch Hetchy dam site, were conducted at the new gaging station, three-quarters of a mile below the dam, the construction of which was almost completed during the year 1914. During 1915 a stone house with reinforced concrete roof was built at this station and the measuring sections for cable work were put in good condition. The work was completed in September and the old gaging

station abandoned, as it was impracticable to continue the record there on account of construction work.

During October and November, 1915, a new station was constructed on Falls Creek, about one-quarter mile above Wapama Falls. Falls Creek is tributary to the Tuolumne River at a point in Hetch Hetchy Valley about one mile above the dam site.

At the Falls Creek gaging station the well is of stone and the house of reinforced concrete. A cable was installed a short distance above the gage. The station is equipped with a Stevens recording gage, the first one of this type to be installed by the City.

The old channel leading from Falls Creek below the gaging station, and diverting water to Tueeulala Falls, which for many years has been almost entirely blocked by logs, some buried deep, was cleared of obstructions.

At Cherry Creek gaging station the old wooden well was replaced by a reinforced concrete well and house. Reinforced concrete anchorage was placed for the cable at the measuring section and a ferry constructed.

At Eleanor Creek a new station was built at a point below the dam site. The well was built of stone to a height of 7 feet and of reinforced concrete above that point. Considerable blasting was required in the construction of this station. The work was completed on November 9th, and a new hydrographic record started on November 13th, at which time the old Eleanor Creek record was discontinued.

SURVEYS

Hetch Hetchy Railroad: The location survey of the Hetch Hetchy Railroad was completed in June, 1915. The line as now located has a total length of 67.63 miles, from the camp at Hetch Hetchy dam site to the connection with the Sierra Railway of California, at a point about one-half mile northerly from Rosasco Siding. The maximum grade is 4% and the maximum curvature 30° or a radius of 191 feet. The grade going east has in all instances been compensated for curvature at the rate of .04% per degree of curve, and going west this condition has been observed from Colfax Gate to Rosasco, with the idea that future developments may warrant the maintenance of a permanent railway from Rosasco, via Groveland, to Colfax Gate, and thence up the canyon of the South Fork to Crocker's or Sequoia. In such event the alignment and grade, as now located, would prove quite feasible for regular railway operation.

The railroad is to have a uniform width of roadbed of 16 feet at sub-grade on both cuts and fills, except for that portion from Hog Ranch, through Yosemite National Park, to Hetch Hetchy dam site, which is 22 feet wide.

Aqueduct Surveys: Upon the completion of the location survey of the Hetch Hetchy Railroad, the survey party was transferred to Early Intake and proceeded to locate the Hetch Hetchy Tunnel Aqueduct from that point to the westerly boundary of the Stanislaus National Forest. The relocation of this line was determined after extensive cost analyses, as well as geological studies.

The new aqueduct line crosses the South Fork of Tuolumne River at a point near the confluence of the Middle Fork, the crossing being a very low bridge. With the old aqueduct location, an expensive inverted siphon would be necessary, in which the water would be under very high pressure. This undesirable feature is eliminated in the revised location, which places this 19-mile section of the aqueduct on a uniform gradient.

The location survey for the new aqueduct line has been completed to the westerly boundary of the Forest, and application maps and field notes to be presented to the Department of the Interior are about to be prepared. Some of this relocation survey was run through the precipitous gorge of the South Fork of Tuolumne River where the surveyors had to be suspended by ropes. The nature of the work required great accuracy and the survey was made with extreme care. Concrete monuments were set on the permanent points of the survey.

A preliminary line has been run from Priest Reservoir to the Moccasin Creek power house site, and thence a location survey has been run to Red Mountain Bar. At this point the aqueduct will cross the Tuolumne River on a structure, the nature of which has not yet been definitely determined. For purposes of study, a detail topographic survey was made of the site of the proposed crossing. The survey has been continued from here to the westerly boundary of Tuolumne County, which will be approximately the end of Tunnel Aqueduct and the head of San Joaquin Valley pipe line.

Miscellaneous Surveys: In December, 1914, the City Attorney requested that this office make a survey of the exterior boundaries of an 80-acre tract owned by the Yosemite Power Company in Poopenaut Valley, some two miles below Hetch Hetchy dam site. This survey was made in January, in the face of great difficulty, owing to the heavy snow fall. A map of the exterior boundaries, with some topography, was made and delivered to the City Attorney's office.

Preliminary to the clearing of the floor of Hetch Hetchy Valley, to the elevation which was to be flooded by the construction of the Diversion Dam, an average depth of about 30 feet, a survey was made of the 3,560-foot contour, which was flagged out on the ground for the guidance of the men engaged in clearing the reservoir site.

The Hetch Hetchy dam site was accurately resurveyed and topographic map made thereof. This map was the basis of final studies of type of dam to be constructed, and also of location of this and various appurtenant structures.

In the operation of the sawmill at Canyon Ranch, governmental regulations of the Yosemite National Park necessitated confinement of our timbering operations strictly to the lands owned by the City at Canyon Ranch. To insure this object, a survey was made of the exterior boundaries of this land. The corners and lines were marked and the sawmill force instructed to keep within them. This work was done in July.

For the purpose of making descriptions of the rights of way along the Hetch Hetchy Railroad, resurveys were made of the townsites of Big Oak Flat and Groveland. The original surveys of these townsites were very

roughly done in the mining days of 60 years ago, and without the resurveys it was impossible to determine with any accuracy the location of the property lines. This work has now been completed and the rights of way are being definitely established as a result of it.

The Indian lands in the Big Creek Valley, near Groveland, were surveyed, as well as a number of mining claims along Moccasin Creek, as the railroad traverses these lands and the descriptions were needed for right of way purposes.

The last survey work done during the year was the beginning of cross-sectioning of the railroad line. For this purpose the survey party was divided, one party working from Rosasco toward Jacksonville, and the other from Jacksonville toward Priest. This cross-section work will determine definitely the yardage of grading done by the contractor under Contract No. 7, for constructing the Hetch Hetchy Railroad.

ALAMEDA CREEK HYDROGRAPHY

The work of gaging the water sources of the Spring Valley Water Company, in Alameda County, begun in 1914, has been continued during the year. The accumulation of accurate data and determination of the reliable yield of these sources is of great importance to the City in connection with not only any future purchase of the Spring Valley Water Company, but of any controversy in which the Company and the City may be involved.

APPLICATIONS TO DEPARTMENT OF INTERIOR

Application map of the Hetch Hetchy Tunnel Aqueduct, from the west boundary of the Forest to Priest Reservoir, was prepared and filed, together with field notes, in the Sacramento Land Office on March 9, 1915, and approved by the Secretary of the Interior on June 1st.

Amended application for Lake Eleanor Reservoir and application for Cherry-Hetch Hetchy Tunnel Aqueduct in Stanislaus National Forest were filed March 9th, and approved, respectively, December 27th and December 24th.

Applications for the following rights of way were also made:

Hetch Hetchy Railroad, from Hog Ranch to west boundary of Forest, filed May 28, approved October 12.

Hetch Hetchy Railroad, from west boundary of Forest to Priest Reservoir, filed June 11, approved October 15.

Hetch Hetchy Railroad, from Priest Reservoir to Red Mountain Bar, filed August 18, approved October 12.

Hetch Hetchy Railroad, from Red Mountain Bar to Rosasco, filed November 1, approval still pending.

During the year the City received the following permits from the United States Department of Agriculture:

Early Intake Camp, 12.83 acres, in Sec. 11, T. 1. S., R. 18 E.
Grouse Springs No. 1 Camp Site, 2 acres, in same section.
Grouse Springs No. 2 Camp Site, 2.8 acres, in same section.
Half Way Camp, Early Intake, 8.25 acres, in same section.

CITY DISTRIBUTING SYSTEM

Pending the settlement of the suit instituted by the Spring Valley Water Company for the adjustment of water rates in San Francisco, realizing that the outlying districts were in urgent need of immediate supply, on the recommendation of this office the Board of Public Works was authorized by Resolution No. 10869 of the Board of Supervisors to sink test holes on property belonging to the City and County in Richmond and Sunset Districts, to determine the feasibility of obtaining a supply from wells in this locality.

Ten test holes were bored and proved the waterbearing possibilities of this district. Contracts were therefore entered into for five wells, the total cost of drilling which amounted to \$13,895.94. The cost of the ten test holes amounted to \$4,250.25. It is estimated that from the wells already drilled a permanent supply of 1,000,000 gallons a day can be secured. Therefore, if it ever becomes necessary to supply portions of the Richmond or Sunset Districts from this source the necessary pumping station can be installed and distributing reservoir constructed.

Subsequent to the drilling of the wells, however, on July 3, 1915, the following Resolution was passed by the Board of Supervisors (No. 11886 New Series):

Whereas, The Spring Valley Water Company has submitted in writing an offer to make certain needed extensions to its water mains in the City and County of San Francisco; and

Whereas, One of the conditions of said offer is that the cost of installing said mains shall be added to any price which may be fixed upon the properties of said Company now under condemnation in suit No. 53708 in the Superior Court of this City and County; now, therefore, be it

Resolved, That the City Attorney is hereby authorized and directed to enter into a stipulation in said case with the Spring Valley Water Company to the effect that the cost of such extensions when completed may be added to the value of the properties found by the Court as of the day on which the summons was issued.

Pursuant to this agreement, the Spring Valley Water Company has installed since July 3, 1915, the following pipes in the various districts:

Richmond District.

- 16" main in 23rd Ave., from Fulton to Geary Sts.
- 12" main in Anza St., 23rd to 29th Aves.
- 12" main in 29th Ave., from Anza to Balboa Sts.
- 12" main in Balboa St., from 29th to 31st Aves.
- 8" main in Balboa St., from 31st to 42nd Aves.
- 8" main in 42nd Ave., from Balboa to Geary Sts.
- 8" main in Fulton St., from 10th to 23rd Aves.
- 8" main in 28th Ave., from Anza to Geary Sts.
- 8" main in 21st Ave., from Anza to Geary Sts.
- 6" main in 18th Ave., from Fulton to Cabrillo Sts.

These mains are all extensions and connections for service from the 30" main laid across Golden Gate Park from Lincoln Way and 19th Avenue to Fulton Street and 23rd Avenue, and form extensions to the main arteries for supply into the district previously supplied with a 16" main in Geary Street extending as far west as 23rd Avenue and north in 23rd Avenue to California Street.

There is a section of this district lying between 9th and 23rd Avenues, and Fulton and Geary Streets, which is served by small pipes, nothing larger than 2" diameter, excepting for a 4" pipe running one block south of Geary Street in 11th and 12th Avenues and a 6" pipe running two blocks south from Geary Street in 21st Avenue. In the section between 23rd and 47th Avenues, between Fulton and Balboa Streets, there are no pipes larger than 2", and there are no pipe lines in Fulton Street. The nearest supply to this district is the line from 29th to 42nd Avenues in Balboa Street, from which laterals could be run to supply the district. A satisfactory water supply for this district might be made by installing a sufficient number of laterals to cover the sections of the district now not supplied in any manner.

Sunset District.

The Spring Valley Water Company has installed the following:

- 16" main in Judah St., from 7th to 19th Aves.
- 16" main in 19th Ave., from Judah St. to Lincoln Way, connecting same with the 30" main across the Park.
- 6" main in Judah St., from 19th to 27th Aves.
- 6" main in 27th Ave., from Judah to Irving Sts.
- 6" main in Irving St., from 27th to 28th Aves.
- 4" main in 19th Ave., from Judah to Quintara Sts.
- 4" main in Quintara St., from 19th to 10th Aves., into Forest Hill.

In view of possible unforeseen emergencies, it is recommended to make further expenditures in the development of wells in the outlying districts, and it is strongly urged that additional waterbearing land be purchased adjacent to the most desirable well sites. With proper pumping stations installed ready for service, this source would provide the same protection for domestic supply that the high pressure furnishes for fire protection. The City would then have in reserve a dependable supply from this source, but its use at the present time would be inadvisable when it is within the power of the Railroad Commission to compel the Spring Valley Water Company to furnish an adequate supply for all purposes.

EXHIBIT "G"

EXPENDITURES ON THE HETCH HETCHY WATER SUPPLY
FROM 1900 TO 1916, AND ESTIMATED ANNUAL EXPENDI-
TURES TO THE END OF THE CONSTRUCTION PERIODI. PRELIMINARY EXPENDITURES, JAN. 1, 1900, TO JAN. 31, 1916,
INCLUSIVE

(Round figures used)

1900-1906:

Engineering expense on preliminary investigations.....\$ 44,000

1906-1910:

General and legal expense.....\$ 9,000

Engineering 14,000

Lands 51,000

Total for period 1906-1910.....\$ 74,000

1910-1911:

General and legal expense.....\$ 26,000

Engineering 40,000

Lands and water rights..... 537,000

Total for period 1910-1911.....\$ 603,000

1912-January 31, 1916:

General and legal expense.....\$ 60,000

General engineering 45,000

Water supply investigations..... 320,000

Railroad surveys and construction..... 200,000

Hetch Hetchy reservoir: surveys, permanent camp, clearing
reservoir, construction of diversion tunnel, road, trails, tele-
phone line, etc..... 150,000Aqueduct: surveys, roads, trails, Early Intake portal excavation,
etc. 74,000

Lands, water rights, rights of way..... 697,000

Total for period 1912-January 31, 1916.....\$1,546,000

Summary for period Jan. 1, 1900, to Jan. 31, 1916:

General and legal expense.....\$ 95,000

General engineering 143,000

Water supply investigations..... 320,000

Railroad surveys and construction..... 200,000

Hetch Hetchy reservoir, preliminary work..... 150,000

Aqueduct surveys and construction..... 74,000

Lands, water rights and rights of way..... 1,285,000

Total\$2,267,000

2. PRELIMINARY WORK YET TO BE ACCOMPLISHED IN THE FIELD BEFORE ACTIVE CONSTRUCTION WORK ON THE VARIOUS PERMANENT FEATURES OF THE HETCH HETCHY SUPPLY DEVELOPMENT CAN BE STARTED

ALL TO BE CARRIED OUT IN 1916, EXCEPT AS OTHERWISE NOTED

Hetch Hetchy Railroad:

Construction now in progress to be completed in 1916; engineering and payments for rights of way; rolling stock, buildings, etc.....\$1,650,000

Lower Cherry Power Development for Construction Purposes:

Storage and diversion dams and canals to be constructed in 1916..\$120,000

Power plant and transmission lines to be constructed early in 1917
so as to furnish power as early as required for dam and tunnel construction 120,000

Total for this power development..... 240,000

Hetch Hetchy Reservoir:

Clearing of reservoir now in progress and diversion tunnel, now under construction, to be completed; diversion dam, roads and trails and additional camp buildings to be constructed; lower part of foundation of dam to be stripped and river channel below dam site to be cleared, etc. 160,000

Aqueduct, Early Intake to Moccasin Creek:

Geological investigation of aqueduct line (diamond drillings); excavation at portals; roads, trails, camps, etc..... 50,000

San Joaquin Valley Pipe Line and Aqueduct Tunnel in Coast Range:

Surveys 15,000

Total cost of above described work.....\$2,115,000

3. PROSECUTION OF CONSTRUCTION WORK FROM 1917 TO THE END OF THE CONSTRUCTION PERIOD

On each of the large divisions of the system the first year of construction will be devoted to the assembling of construction plant and materials and the commencement of work on permanent construction. At the dam this construction will embrace the continuation of the foundation stripping and the beginning of the concrete construction. On the aqueduct tunnels work will be started from the portals and the sinking of shafts will commence during the first year.

The rate at which the work is to be carried on is indicated by the cost figures on the following page. The table on that page also shows the correlation of the various features of the work so as to bring all parts of the system to completion at the same time.

EXHIBIT "G"—Continued

SCHEDULE OF EXPENDITURES FOR HETCH HETCHY WATER SUPPLY SYSTEM

(City Distributing System Not Included)

YEAR	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13
		General engineer- ing, legal expense, water supply in- vestigations, by topography	Lands, water rights, rights of way	Hetch Hetchy Railroad	Lower Cherry Ca- nal and Temporary Power Plant	Hetch Hetchy Reservoir	Tunnel Early Intake to Moc- casin Creek	Tunnel Mocca- sin Creek to San Joaquin Valley	San Joaquin Valley pipe line	Coast Range Tunnel	Pipe line Irving- ton to San Francisco	Moccasin Creek Power Plant, in- stallation, 37,500 K. W.	Totals for entire system
1900 to 1915.....	\$558,000	\$1,285,000	\$ 25,000	\$ 200,000	.....	\$ 150,000	\$ 74,000	.....	.....	.....	.....	.....	\$ 2,267,000
1916.....	\$ 65,000	.....	.....	\$1,650,000	\$120,000	\$ 160,000	\$ 50,000	.....	\$ 5,000	\$ 10,000	.....	.....	\$ 2,085,000
1917.....	.....	.....	.....	.....	120,000	700,000	750,000	\$ 10,000	30,000	125,000	.....	.....	1,745,000
1918.....	Expenditures under these two heads after	.....	.....	Cost of operation and	.....	900,000	1,300,000	40,000	65,000	1,000,000	\$ 10,000	.....	3,345,000
1919.....	1916 are included in	.....	.....	maintenance of rail- road and power plant	.....	1,100,000	1,300,000	150,000	300,000	1,500,000	40,000	.....	4,600,000
1920.....	construction costs of	.....	.....	is included in con- struction cost of res- ervoir and aqueduct	.....	1,140,000	1,300,000	500,000	700,000	2,000,000	250,000	.....	7,740,000
1921.....	and power plant.	.....	.....	.....	.....	.....	1,300,000	1,000,000	1,300,000	2,000,000	700,000	\$1,400,000	8,000,000
1922.....	.....	.....	.....	.....	.....	.....	.....	1,200,000	1,300,000	3,000,000	1,300,000	.....	6,800,000
1923.....	.....	.....	.....	.....	.....	.....	.....	1,100,000	1,300,000	3,000,000	1,265,000	.....	6,665,000
Totals	\$623,000	\$1,310,000	.....	\$1,850,000	\$240,000	\$4,150,000	\$6,074,000	\$4,000,000	\$5,000,000	\$12,635,000	\$4,865,000	\$3,400,000	\$44,147,000

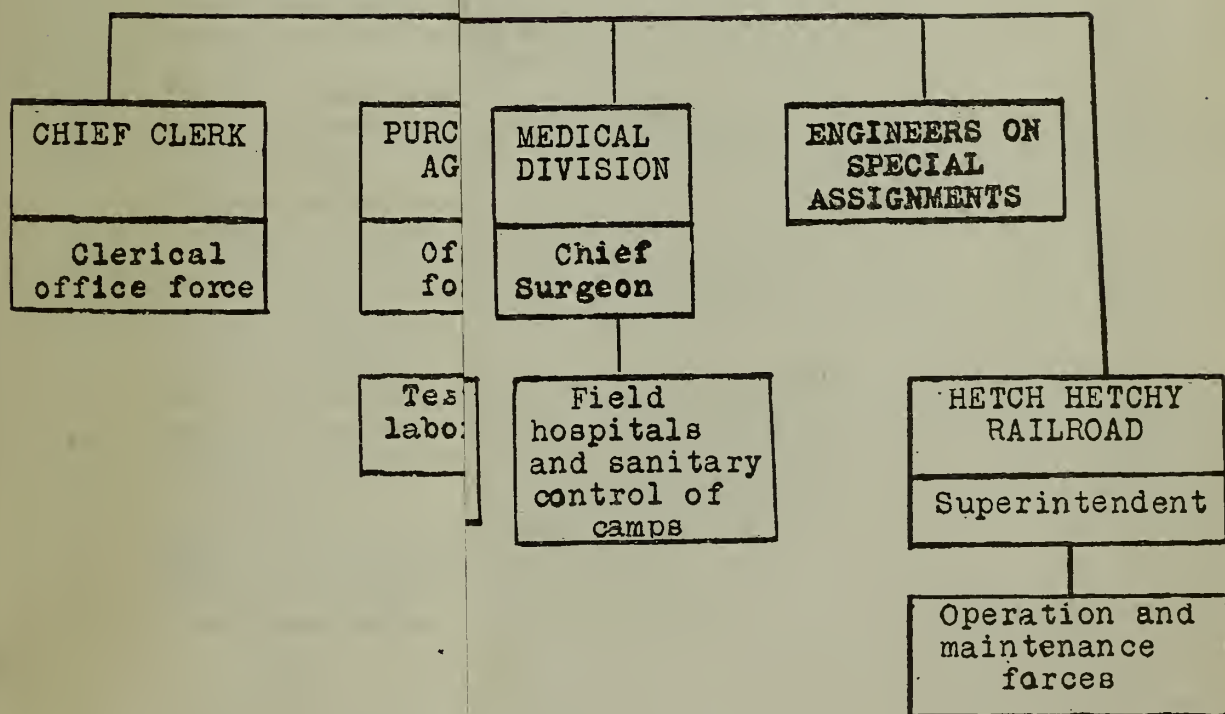


EXHIBIT "H"

HETCH HETCHY WATER SUPPLY

TENTATIVE ORGANIZATION OF ENGINEERING FORCE FOR CONSTRUCTION

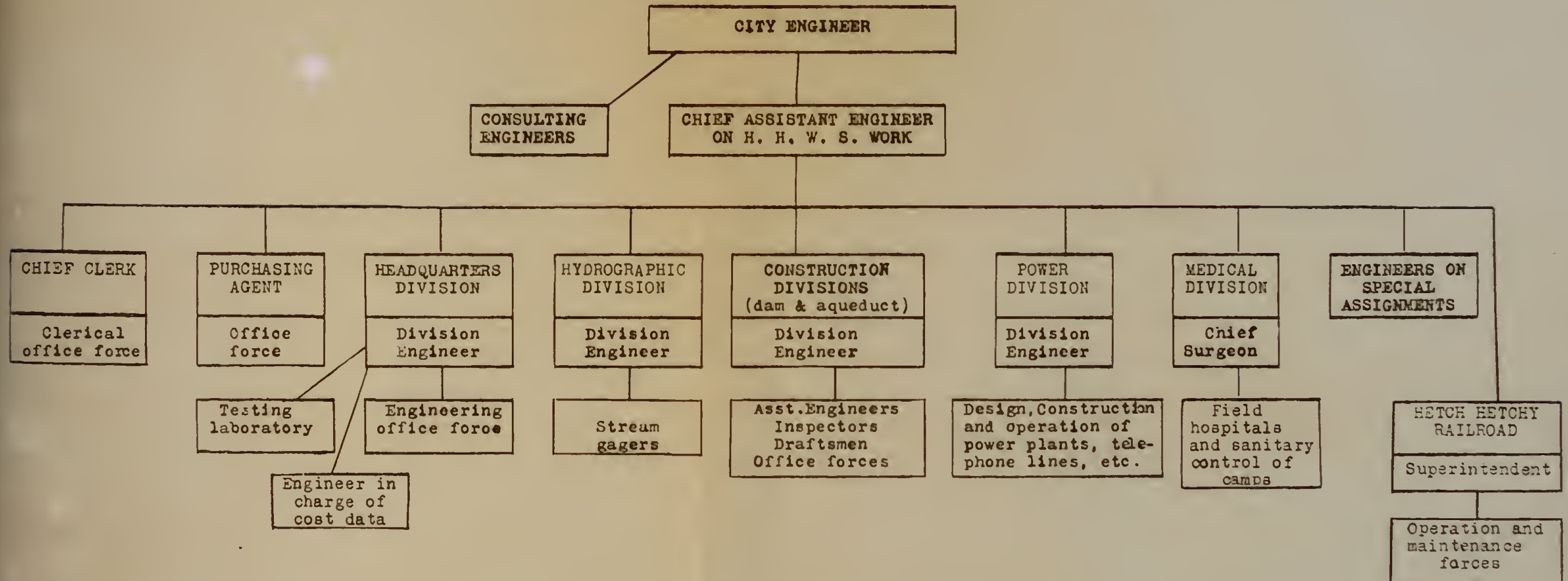


EXHIBIT "I"
CONDITION OF HETCH HETCHY APPROPRIATIONS
FEBRUARY 4, 1916

	Amount Appropriated.	Amount Expended.	Balance.
Closed Accounts—			
City Engineer's part salary.....	\$ 5,000.00	\$ 5,000.00	.....
Co-operative road work.....	3,500.00	3,500.00	.....
Hog Ranch Road to Hetch Hetchy dam site...	180,943.84	180,943.84	.....
Hydrographic data for government.....	5,000.00	4,999.70	.30
Investigating sources of water supply, B. P. W.	140,651.29	140,408.29	243.00
Lake Eleanor	45,000.00	25,476.32	19,523.68
Investigating McCloud River project.....	500.00	500.00	.....
Priest's Hill, construction of roads.....	2,500.00	2,500.00	.....
Engineer's appraisal of Spring Valley water system	3,500.00	3,500.00	.....
Investigating claims of Spring Valley Water Co. in Alameda County.....	1,400.00	1,400.00	.....
Boring test holes in Richmond and Sunset Districts	5,137.01	5,137.01	.....
Investigating Turlock and Modesto Irrigation District	500.00	318.90	181.10
Open Accounts—			
City Engineer's investigation of Hetch Hetchy	2,000.00	2,000.00	.....
Clearing Hetch Hetchy Reservoir.....	43,000.00	17,032.21	25,967.79
Diversion tunnel and diversion dam at Hetch Hetchy	90,500.00	51,061.50	39,438.50
Purchase of gaging apparatus and instruments	5,000.00	1,715.58	3,284.42
General office work, plans, etc.	31,000.00	23,566.58	7,433.42
Hydrography, by B. P. W.	13,000.00	11,031.01	1,968.99
Installing sawmill	13,000.00	12,992.20	7.80
Inspection and engineering in field.....	8,000.00	6,369.81	1,630.19
Inspection of track material for Hetch Hetchy Railroad	900.00	.....	900.00
Insurance with State Compensation Fund....	1,000.00	228.90	771.10
Operating sawmill	14,000.00	12,912.01	1,087.99
Permanent camps and equipment.....	18,500.00	16,284.92	2,215.08
Roads, trails and surveys.....	72,250.00	71,665.14	584.86
Surveys, aqueduct location	9,500.00	7,188.92	2,311.08
Surveys, railroad location	8,000.00	7,932.23	67.77
Telephone lines, Hamilton to Hog Ranch or Portulaca, etc.	5,000.00	4,987.56	12.44
Test borings	5,000.00	.....	5,000.00
Timber cut on government lands.....	1,000.00	452.81	547.19
Water rights and protective work.....	20,000.00	13,702.93	6,297.07
Drilling wells on City property in Richmond and Sunset Districts	15,997.05	14,534.43	1,462.62
Totals	\$770,279.19	\$649,342.80	\$120,936.39

The above are the various accounts of the 1910 Water Construction Bond Fund, showing the amounts appropriated and expended out of same by Board of Public Works up to February 4, 1916, as taken from the books of the Bookkeeper of the Board of Public Works.

EXHIBIT "J"

**APPROPRIATIONS REQUESTED FOR HETCH HETCHY WATER
SUPPLY WORK TO BE EXECUTED FROM MARCH
TO DECEMBER, 1916**

1. Hydrography	\$ 12,000
2. Surveys, aqueduct, San Joaquin Valley, etc.	15,000
3. Water rights and protective work.....	30,000
4. Test borings on aqueduct line (additional to \$5,000 already appropriated but not yet used).....	20,000
5. Headquarters engineering, including consulting engineers, geological studies and general office expense.....	75,000
6. Roads and trails	20,000
7. Inspection and engineering in field.....	35,000
8. Permanent camps and equipment.....	24,000
9. Operation of sawmill, 1916.....	10,000
10. Diversion tunnel and diversion dam.....	23,000
11. Foundation work for main Hetch Hetchy dam.....	52,000
12. Railroad equipment and buildings.....	50,000
13. Lower Cherry power development for construction purposes.....	100,000
14. Acquisition of necessary rights of way through privately owned lands....	500,000
Total	\$966,000

Appropriations for the construction of the Hetch Hetchy Railroad and the clearing of the Hetch Hetchy reservoir site have already been made.

EXHIBIT "K"

**MEDICAL SERVICE, ACCIDENTS TO EMPLOYEES—
LOS ANGELES AQUEDUCT**

3rd Annual Report (Nov., 1908), p. 58:

The organization of a medical department for and in conjunction with the construction of the Los Angeles Aqueduct, and for the benefit of its employees, was authorized by a resolution of the Board of Public Works. On May 13th, 1908, a contract was signed between the Board of Public Works and Drs. Rea Smith, E. C. Moore, and Raymond G. Taylor, wherein the latter agreed to undertake the organization, equipment and administration of such a Department.

Synopsis of Contract.

The Department is supported by assessments from all Aqueduct employees including those of Contractors and Sub-contractors.

Assessments are \$1.00 monthly from those receiving a wage of \$40.00 or over per month, and 50 cents from those receiving less. Any employee is entitled to Medical, Hospital and Surgical service when needed, except for venereal diseases, intemperance, vicious habits, injuries received in fights, or chronic diseases acquired before employment.

Hospitals are of two kinds: Field, erected by the city at suitable points, with accommodations for six patients, surgeon and nurse; and General, located in Los Angeles. The city is to provide wagon transportation for supplies from the railroad to suitable points of the work, and wagon transportation for sick and injured on the work, to Field Hospital or railroad.

Meals, food, water, etc., are furnished by the city and its Contractors to the Medical Department at regular rates at the various camps. Gasoline is furnished by

the city at cost, plus 10%. The City grants the use of the telephone and telegraph lines owned and controlled by it.

Contractors agree to furnish and equip Hospitals, provide Physicians, Nurses and Stewards; to furnish drugs, nursing and medical and surgical attention; to furnish board for bed patients in the Field, and all patients in the General Hospitals; to furnish railroad transportation, where necessary, to the General Hospital and return fare, provided patients re-enter Aqueduct service within five days of their discharge from Hospital.

Contractors are empowered to make sanitary inspection and establish quarantine if necessary.

Organization.

In the practical working out of the plan contemplated in the Contract, several additions, with the idea of giving better and more efficient service, have been made.

Three classes of Hospitals have been established: Camp or Tent, Field or Division, and General.

A Camp or Tent Hospital is located in every camp on the work. It consists of a 14x16 wall tent, framed and floored, and is practically wind and rain proof.

Each division is divided into sections.

The Camp Hospitals in each section are in charge of the Hospital Steward, who is provided with a saddle horse and makes daily trips to all camps in the section.

Field or Division Hospitals are located at Division headquarters and, where practicable, on the railroad. They are built of wood, and normally accommodate six patients (the Jawbone Hospital accommodates twelve), Hospital Stewards and Surgeons. They are headquarters for the Division Surgeons, and distributing points for supplies.

The General Hospital is the California Hospital, located at Los Angeles, and all severe cases that cannot be properly cared for in the field are removed to it. Arrangements have been made by the Contractor with the management of the Hospital whereby Aqueduct patients requiring General Hospital care are received and given exactly the same care and attention as any private patient.

Surgeons are of four classes: 1st—Consulting Surgeons, who are Specialists in their various lines. 2nd—Chief Surgeons, in direct charge and management in the Department. 3rd—Assistant or Division Surgeons, in charge of Field or Division Hospitals and tributary Camp Hospitals and Stewards. 4th—Local or resident Surgeons, who, while not located at a Field Hospital, reside in the neighborhood and are subject to call at any time.

Hospital Stewards are located at all Field or Division Hospitals and at such Camp or Tent Hospitals as the necessities of work demand. Their duties are to prepare food, administer the details of treatment and nursing, and give first aid to the sick and injured. They are under the supervision and report to the nearest Division Surgeon.

Inspection and Sanitation.

An inspection trip is made by the Contractors over the whole line of the Aqueduct once a month. Short trips to the principal points on the work are made several times per month, as necessity may require.

Sanitary conditions are inquired into not only on these trips of inspection, but constantly by the Division Surgeons and the Hospital Stewards, who are over the ground daily. Unsanitary conditions of the camps, bunk houses, mess house, commissary, water supply, drains or toilets, if found, are at once brought to the attention of the engineer in charge and immediately remedied. The camps are well policed at this date and in good condition.

Equipment.

Camp or Tent Hospitals are equipped with stoves for heating and simple cooking, and cooking utensils, basins, irrigators, etc., and material for doing ordinary surgical

dressings; medicine chest and medicines; three cot beds with bedding; stretchers for emergency use in case of accident on the work.

Field or Division Hospitals.

Field or Division Hospitals are provided with operating room and appliances for doing practically anything that may be required in the medical or surgical line; a complete supply of drugs and dressings and disinfectants; iron cots with sanitary springs, wool mattresses and bedding; stoves and utensils for heating and cooking; bath tub, slop hopper and sewer connections.

General Hospital.

The General Hospital is one of the best and most completely equipped Hospitals on the Pacific Coast, and all its conveniences and equipment are at the disposal of this Department for the benefit of its patients.

Location of Hospital, Surgeons and Stewards.

Camp or Tent Hospitals have been erected at all the principal camps except those camps having Field Hospitals. About fifteen are in use at present and more are constantly being erected as the work of construction extends.

6th Annual Report (1911), p. 72:

Personal Injuries:

From the beginning of construction work on the Aqueduct to the date of this report, 653 cases of injury to employes have been reported to this department for investigation. This total, however, includes all cases, no matter how slight the injury and regardless of whether or not the employee lost any time by reason thereof. In pursuance of the policy adopted by the Board of Public Works, half pay has been allowed during the period of disability due to such injuries, to 325 of the injured employees, the total amount paid out on such half pay allowances being \$12,454.58. In eight cases, the employees have made claim for damages. An aggregate sum of \$7,750 has been paid in settlement of such damage claims, and there are three suits for damages still pending against the city growing out of personal injuries received by employees on the Aqueduct.

7th Annual Report (1912), p. 88:

Personal Injuries:

During the fiscal year ending June 30, 1912, four hundred and forty-six (446) cases of injury to employees have been reported to this Department for investigation. This total, however, includes all cases, no matter how slight the injury and regardless of whether or not the employee lost any time by reason thereof. In pursuance of the policy adopted by the Board of Public Works, half pay and settlements to the amount of Eight Thousand Five Hundred One and 4/100 Dollars (\$8,501.04) have been allowed as compensation for said injuries.

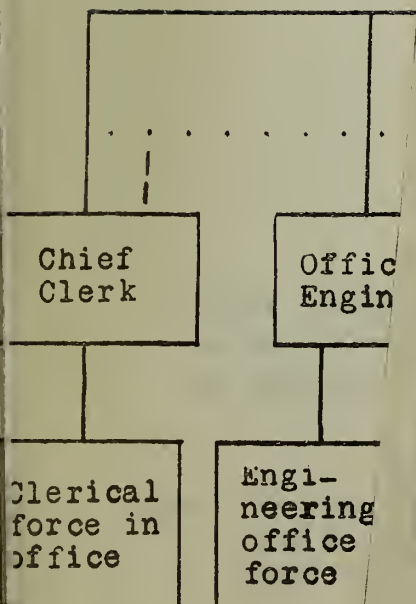
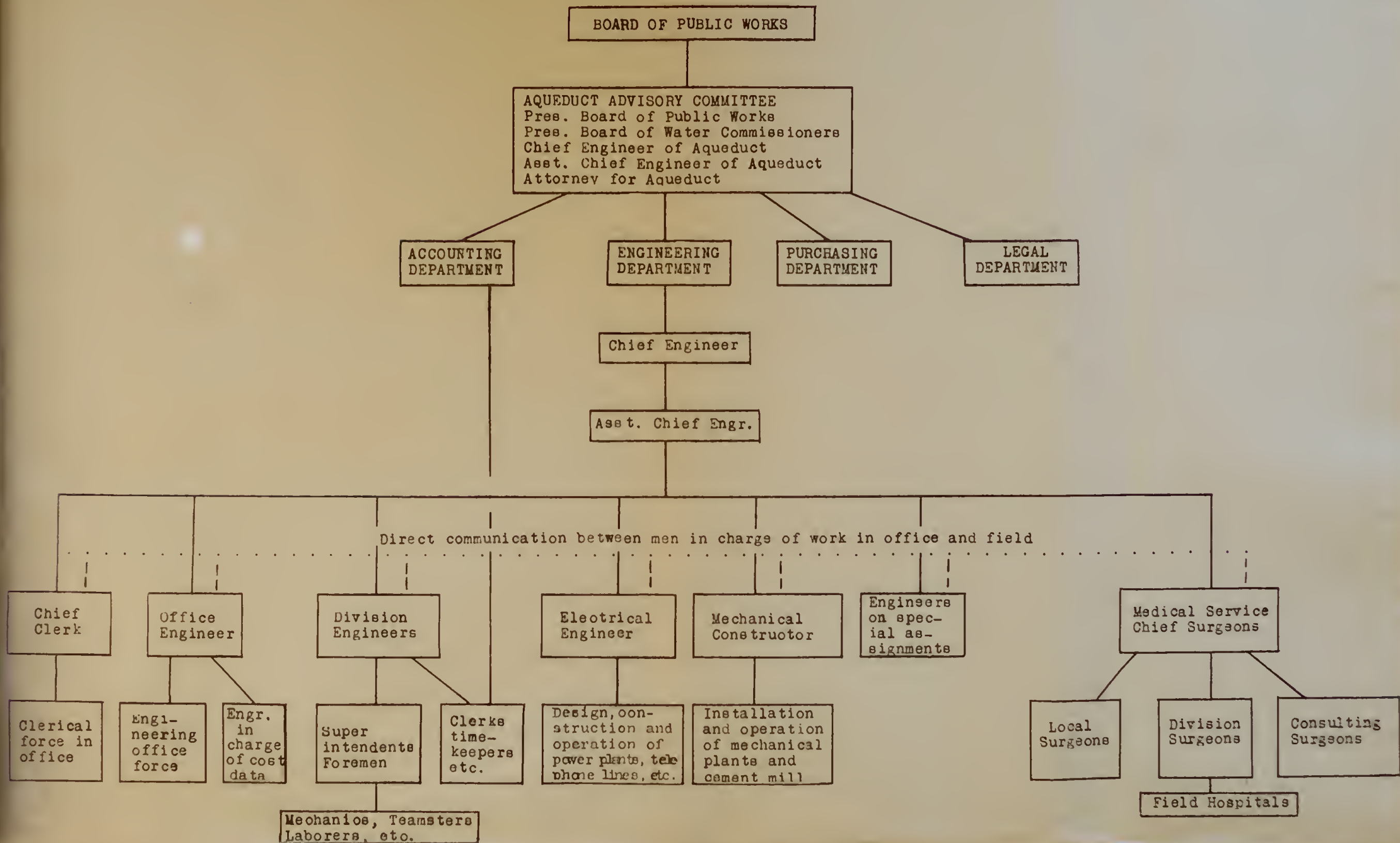
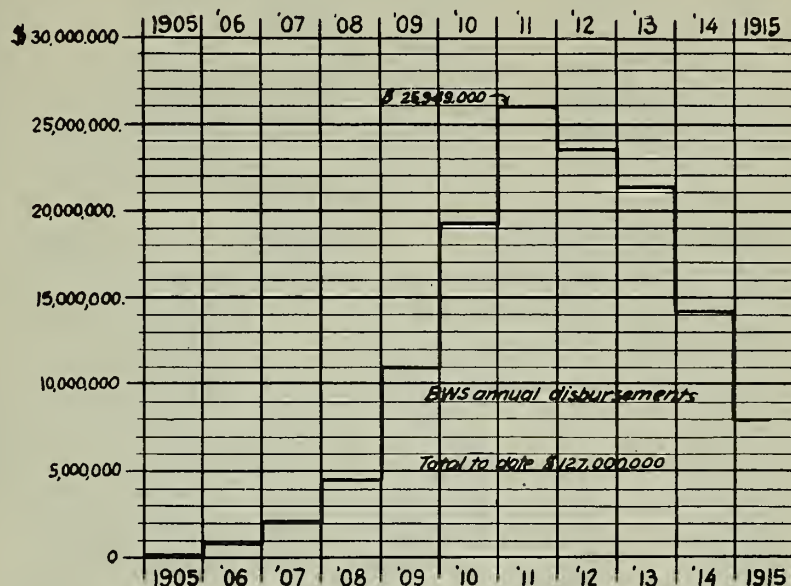


EXHIBIT "L"

LOS ANGELES AQUEDUCT

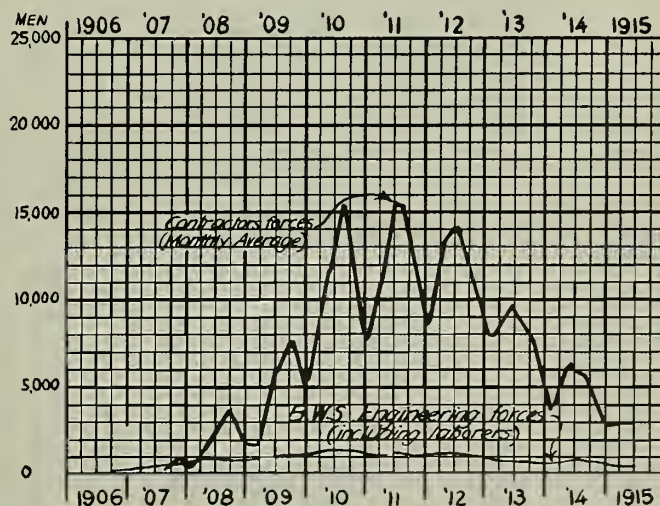
ORGANIZATION OF ENGINEERING FORCE DURING CONSTRUCTION PERIOD





Total estimated cost of Catskill Water Supply \$177,000,000

DIAGRAM OF THE ANNUAL EXPENDITURES, TO THE MIDDLE OF 1915, OF THE BOARD OF WATER SUPPLY



This diagram shows the contractors' working force, reaching a maximum of about 17,000; and the engineering force, at the bottom, which reaches a maximum of about 1,325.

Note: Traced from paper "The Present Status of the Catskill Water Supply for New York City," by J. Waldo Smith, Chief Engr., Board of Water Supply, dated September 1915.

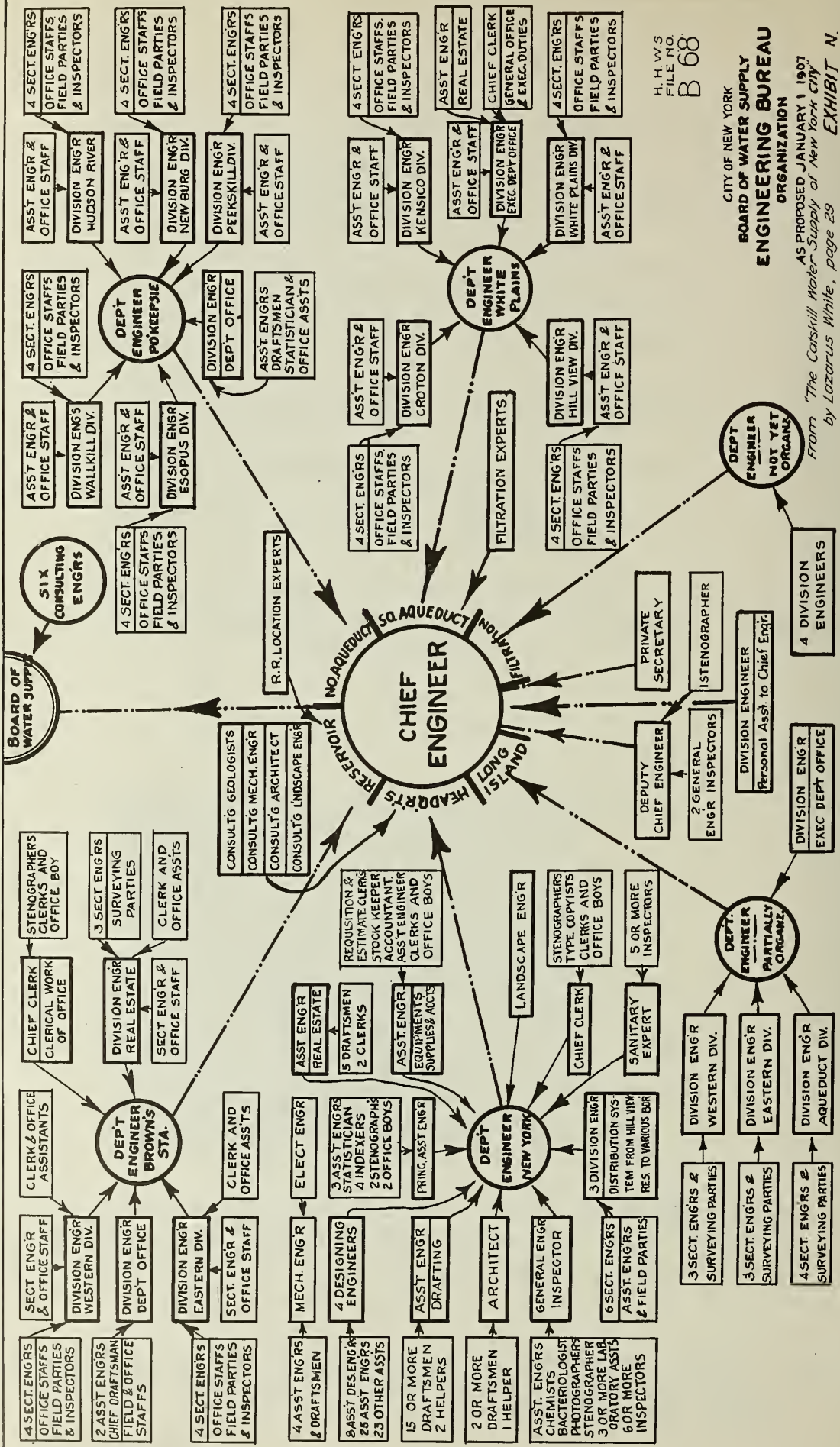
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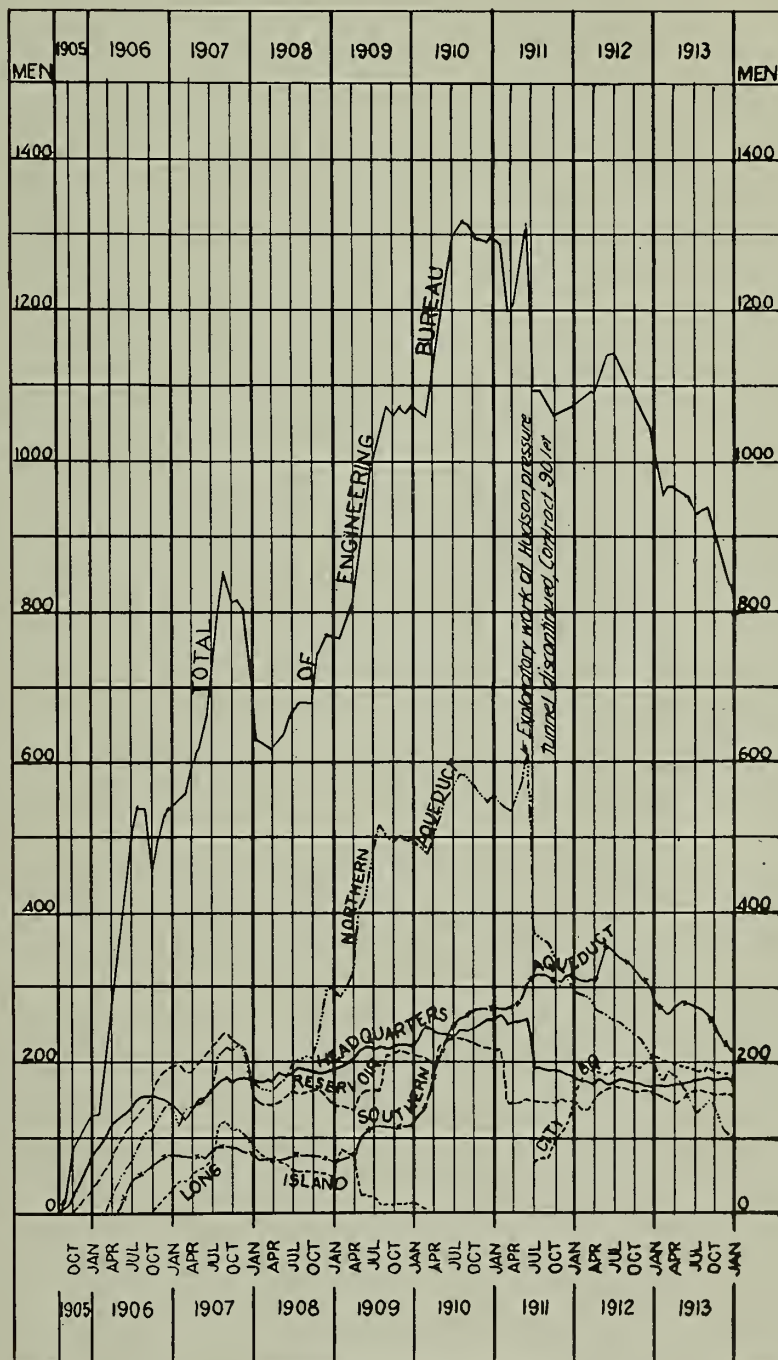
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CITY OF NEW YORK
BOARD OF WATER SUPPLY
ENGINEERING BUREAU
ORGANIZATION

AS PROPOSED JANUARY 1 1907
From "The Catskill Water Supply of New York City"
by Lazarus White, page 29
EXHIBIT

EXHIBIT N.





CATSKILL WATER SUPPLY OF THE CITY OF NEW YORK,
FLUCTUATIONS IN ENGINEERING BUREAU FORCES.

Note: From 8th Annual Report of the Board of
Water Supply. -

EXHIBIT O.



